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ABSTRACT

These hearings focused on various topics and issues related to the fiscal year 1985 budget request of $1.5 billion for the National Science Foundation (NSF), which represents a 13 percent increase over the 1984 level, as well as on NSF policies. Witnesses, representing government or scientific and technical organizations not directly part of the NSF adminsistration, who presented testimony and/or prepared statements included: Edward Knapp (NSF director); Lewis Branscomb (chairman, National Science Board); Mary Good; Anna Harrison; Robert Rosenzweig; Russell Drew; Henry Aaron; Joe Wyatt; Ronnie Flippo; Robert Kersten; Robert Baker; Frank Press; J. Thomas Ratchford; Donald Glower; Myron Tribus; and Richard Nicholson (accompanied by Carl Hall). Among the areas considered by these individuals were: overall research priorities of the NSF; supercomputers and proposed centers for cross-disciplinary research in engineering; university instrumentation and scientific equipment needs; science and mathematics education; and engineering education. Highlights for the FY 1985 budget request for specific NSF programs (such as mathematical and physical sciences, engineering, and scientific, technological and international affairs) are included. Also included in an appendix is a statement by the National Institute for Entrepreneurial Technology. (JN)

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[illegible] NATIONAL SCIENCE FOUNDATION AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

[illegible] CONGRESS

[illegible] SESSION

ON

H.R. [illegible]

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Printed for the use of the
Committee on Science and Technology

1985 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

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ON

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FEBRUARY 3, 9, 28, 29; MARCH 21, 1984

[No. 93]

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1985 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

FRIDAY, FEBRUARY 3, 1984

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:37 a.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Lundine, Lujan, and Skeen.

Mr. Walgren. Let me call us to order.

Today the Subcommittee on Science, Research and Technology begins several hearings on the fiscal year 1985 National Science Foundation authorization. This hearing today will primarily be an overview of the Science Foundation's budget request and the policies of the Foundation. Subsequent hearings will deal with the individual programs in great detail.

The budget request for 1985 is $1.5 billion, which represents a 13-percent increase over the 1984 level. This request continues the administration's policy of providing real growth for Federal support of basic research, a policy that certainly has broad and bipartisan support on this committee.

We are particularly interested in exploring new NSF initiatives in such areas as:

Supercomputers and associated computer networks; developing the engineering program in response to engineering needs, science and mathematics education at all levels but certainly at the precollege level as well; instrumentation and scientific equipment needs at our Nation's universities and colleges.

Indeed, these are initiatives that our committee has encouraged NSF to undertake for the past few years. Certainly our committee has tried to support them when they moved in that direction.

We are pleased to see them in the fiscal year 1985 request, along with strong support for all of the scientific disciplines. I am especially gratified to see that real growth is requested for the social, behavioral, and economic sciences that had experienced a hiatus years ago.

There is concern, however, about the funding level for supercomputer initiatives, and whether they adequately address the urgent national need in this area that we have heard so much about recently. We also want to explore the effectiveness of the NSF's present organizational structure to support new and rapidly emerging, interdisciplinary fields, such as genetic engineering, biotechnology, robotics, and the like.

I would also like to ask for some discussion and hopefully reassurance about the future of the Foundation's Division of Policy Research and Analysis and particularly whether or not that arm of the Foundation will have a balance of support for both short-range and long-range studies and that a program of extramural support of that area will also be maintained.

To discuss these issues, we have with us today the Director of the National Science Foundation, Dr. Knapp, and Dr. Branscomb, the Chairman of the National Science Board. It is a pleasure to welcome both of you back before the subcommittee. We are especially pleased that you would come.

I understand our scheduling problems have put us on a day when some members were unable to be here, and I apologize for that. But we are very interested in building a record and opening an avenue of discussion about the particulars of this year's plans that the administration has for the National Science Foundation in hopes of being supportive of the directions that we should go.

So with that, let me invite Dr. Knapp to begin. As you know, Dr. Knapp, any written submissions you would like to make will be made part of the record automatically, and we would be pleased to have you proceed with your statement.

[Biographical sketches of Dr. Knapp and Dr. Branscomb follow:]

NATIONAL SCIENCE FOUNDATION
WASHINGTON D.C. 20550

DR. EDWARD A. KNAPP

Director

Dr. Edward A. Knapp became Director of the National Science Foundation in a recess appointment announced on November 2, 1982, by President Reagan. He was subsequently confirmed by the Senate on April 15, 1983. He had been Assistant Director for Mathematical and Physical Sciences of the NSF since September 16, 1982. Prior to coming to the NSF, he was head of Los Alamos National Laboratory's Accelerator Technology Division in Los Alamos, New Mexico.

Dr. Knapp was born in Salem, Oregon, on March 7, 1932. He earned his A.B. degree in physics in 1954 from Pomona College, and his Ph.D. degree in high energy physics from the University of California (Berkeley) in 1958. He joined Los Alamos National Laboratory in 1958 and was involved with the pioneers of the Manhattan Project in the early work on controlled thermonuclear research.

Dr. Knapp participated in the initial planning for the Laboratory's half-mile-long linear proton accelerator, the Los Alamos Meson Physics Facility (LAMPF). While LAMPF was being constructed, Dr. Knapp specialized in accelerator physics and headed the research group that designed the accelerator structures for the facility. These systems were also utilized in industry, and ultimately led to a compact electron accelerator that is now used by more than 500 institutions for radiation therapy of cancer.

In 1972, Dr. Knapp spent a sabbatical at the European Organization for Nuclear Research (CERN) in Switzerland, where he worked on the design of a new proton accelerator for that facility and the development of a collaborative high-energy physics program involving Los Alamos and CERN. On returning to Los Alamos in 1973, he assumed responsibility for the applied physics program and for the medical pion beam at LAMPF that was used successfully for the treatment of several types of cancer.

Dr. Knapp is a Fellow of the American Physical Society, a member of many scientific and technical organizations, and is the co-author of almost 100 scientific papers. He has served on many panels and committees in his fields of interest.

May 1983

LEWIS M. BRANSCOMB

Vice President and Chief Scientist

International Business Machines Corporation

Dr. Lewis M. Branscomb, Vice President and Chief Scientist of International Business Machines Corporation, and a member of the Corporate Management Board, is responsible for guiding the corporation's scientific and technical programs to ensure that they meet long-term needs. He joined IMB as chief scientist in May 1972 and was then elected an IBM vice president. In March 1983 he was named a member of the Corporate Management Board.

A research physicist, Dr. Branscomb was appointed director of the National Bureau of Standards by the President in 1969. He joined the Bureau in 1951, served as chief of the NBS Atomic Physics Division, and was chairman of the Joint Institute for Laboratory Astrophysics at the University of Colorado before his appointment as director of NBS.

In 1979 Dr. Branscomb was appointed by President Carter to the National Science Board, and in 1980, he was elected chairman. He is also a member of the President's National Productivity Advisory Committee and chairs its Subcommittee on Research, Development and Technological Innovation.

Dr. Branscomb was graduated from Duke University summa cum laude in 1945. He was awarded M.S. and Ph.D. degrees in physics by Harvard University in 1947 and 1949. During his career, he has taught at University College, London, the University of Maryland, the University of Colorado, and Harvard where he was a member of the Society of Fellows.

Dr. Branscomb has received the Rockefeller Public Service Award, the Samuel Wesley Stratton Award, the Gold Medal for Exceptional Service from the United States Department of Commerce, the Procter Prize from the Scientific Research Society of America, and the National Civil Service League Award. He holds honorary doctor of science degrees from Duke, Western Michigan, and Rochester Universities, the Universities of Colorado and Alabama, Polytechnic Institute of New York, Clarkson College of Technology, and Lycoming College, and an honorary doctorate in humane letters from Pace University.

Among his affiliations, Dr. Branscomb has been a member of the President's Commission for the Medal of Science and the President's Science Advisory Committee. A member of the National Academy of Engineering, the Institute of Medicine, the National Academy of Sciences, American Philosophical Society, Royal Society of the Arts and past president of the American Physical Society. He has served on the U.S. Department of State's Advisory Committee on Science and Foreign affairs, and is a former member of the board of directors of the American Association for the Advancement of Science.

Dr. Branscomb is a director of General Foods Corporation and Mobil Corporation, and a trustee of the Carnegie Institute of Washington and Vanderbilt University.

Dr. and Mrs. Branscomb have two children.

Mrs. Branscomb is an attorney.

# # #

May 1983

STATEMENT OF DR. EDWARD A. KNAPP, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. **Knapp**. Thank you, Mr. Chairman.

Mr. Chairman, members of the committee, it is a pleasure to be with you today for the first of 2 days of hearings on the administration's fiscal year 1985 budget request for the National Science Foundation. The administration has requested a strong, well-balanced budget. It will build upon the strong budget that the administration requested and the Congress approved for the current fiscal year.

Realizing the most critical goals of our Nation—sustained economic growth enhanced national security, and improved quality of life—will depend critically on how well we develop and apply new scientific and engineering knowledge. And our ability to develop and apply that knowledge will depend on persuading our most talented young people to pursue careers in science and engineering.

Meeting these two needs—the need for knowledge and the need for people who can use it—is the mission of the National Science Foundation. Before discussing further the current budget request, I would like to take just a few minutes to show you a short film that provides some examples of how we go about meeting these needs.

[Whereupon, a film was shown.]

Dr. **Knapp**. Mr. Chairman, in view of the continuing support and encouragement of this committee, I believe you will be pleased to know that the administration's fiscal year 1985 budget request for the Foundation totals just over $1.5 billion. This represents an increase of almost $182 million, or 13.7 percent above the fiscal year 1984 current plan. The request includes $1,308 million for research and related activities, $115 million for the U.S. Antarctic program, $75.7 million for science and engineering education, and $2.8 million for special foreign currency.

The activities which these funds will support are selected through a complex planning process which begins with consideration of major policy issues by the National Science Board. The Board's policy statements then inform our long-range planning process and are a major factor in selecting specific budget priorities. I am especially pleased that Dr. Lewis Branscomb, Chairman of the National Science Board, is here today to highlight five major policy issues which the Board has dealt with in the recent past.

STATEMENT OF DR. LEWIS M. BRANSCOMB, CHAIRMAN, NATIONAL SCIENCE BOARD

Dr. **Branscomb**. Thank you. I am Lewis Branscomb, Chairman of the Science Board. Let me start by saying that I hope you enjoyed that film as much as I did. I had not seen it before, and it reminds me that when we testify about the science budget and about policy, we often, I think, lose sight of the beauty and the substance of what science is all about when we are discussing these policy issues in somewhat more abstract terms.

I am going to try to deal very briefly and concisely with a set of those policy issues in a moment, but I just wanted to say I think that the enthusiasm and support that the American people have for the scientific leadership of this country rests in an important way on their appreciation of what the substance of science is really all about, and I thought that that film did a very nice job of relating science to a kind of higher order of common sense, of human adventure, and that is an important part of what we are all about and something I think none of us want to lose sight of while we are trying to manage our investments to get the maximum value, both short and long term, for the American people.

I would like to touch on several of the Board's recent activities that bear on the strategy behind this budget, the priorities in it, and the policy issues that are associated with its implementation.

The President's 1985 budget contains some important priorities in a number of areas that the Board has been paying a great deal of attention during the last 2 years. I want to touch on five areas: One, industry-university research cooperation; two, research in and access to scientific computing; three, science in the international setting; four, science and engineering education; and, five, the engineering mission of the NSF. The committee has the documents and statements to which I will refer; of course, we will be happy to provide additional copies to committee members and the staff.

While I am going to focus on five policy issues, I do want to reiterate that the most important thing in this budget is the investment that it provides for in scientific research in many disciplines to be able to respond to the exciting areas that are identified by investigators and the system that selects those who are to receive grants, for it is the forefront scientific research that has given us a leadership position, and unless we keep that fundamental research enterprise vital and competitive, all of our efforts to commit science more strongly to national goals will not be effective.

The Board's annual report to the President and the Congress last year highlighted the growing importance to both universities and to industrial firms of university/industry research cooperation. The studies that lay behind that short report have very recently been published and made available to the committee. They describe a dynamic situation with a rapid growth of scientific and engineering collaboration, driven by natural forces, not by some artificial perception that this is a popular notion, and I believe that this will be good for both groups of institutions.

The Foundation was very early in encouraging and helping to trigger this development and the Foundation continues to nurture it. This year's budget includes a major focus on making our investments in fields where university/industry relationship will not only advance science but also have the most immediate benefit to the economy, and I cite as examples engineering research, computer science, computers and related disciplines.

Indeed, there are many initiatives in the private sector in parallel with initiatives that the Foundation is taking, and it is the combination of the two that make me have a growing confidence that the Foundation's fundamental research investments will indeed be quickly translated and multiplied in terms of economic benefit to our people.

One of the most radical revolutions that is proceeding in science and in engineering is the role that computers play. The Board has encouraged the Foundation to respond both to the need to enhance access by research scientists to large-scale scientific computers and to support some very exciting research in new ideas for the science of computers.

Dr. Peter Lax of New York, who is a member of our Board, headed a study team that brought these issues before the Board and headed a group sponsored by DOD and NSF that prepared the report of the Panel on Large-Scale Computing in Science and Engineering. This report presented the need for making advanced computing resources available to the research communities. The Director then organized a series of internal studies which the Board reviewed and endorsed. They have led to an initiative in this budget to begin upgrading the access by scientists and engineers to large-scale computing resources.

In a 1982 policy statement the Board concluded that the nature of science required that its international dimension be considered an organic aspect of the research enterprise and be actively provided for in all Foundation programs. The Director recently reported to us on the implementation steps he has taken and the strategies that he has developed to achieve the Foundation's goal of advancing the Nation's scientific and engineering research through international cooperation.

The Foundation's implementation of the policy of broad participation by all programs in international science should lead to more effective use of our resources and a stronger role for the United States in international issues in which we have a stake. The Board, through its Committee on International Science, which is still actively at work under the chairmanship of Professor Nierenberg, continues its support for the important role we see for the Foundation and its Director in international scientific activities.

The Commission on Precollege Education in Mathematics, Science and Technology was established by the Board and completed its work last September. Our expectations for this Commission were high and we were not disappointed. This extraordinarily capable and hard-working group of people produced a report that will provide the framework for action for years to come.

In its resolution accepting the report, the Board strongly endorsed the Commission's view that the rebuilding of American educational superiority in mathematics, science, and technology is essential to the country and must be achieved through the efforts of State and local governments and local communities, stimulated and assisted by Federal leadership that makes educational goals a national priority and provides support for new approaches to mathematics, science and technology education.

Based on the work of the Commission and the Board's implementation policy, we have defined a role for the Foundation that represents admittedly a very small fraction of the national investment of over $100 billion but a potentially very influential role in the quality of mathematics and science education. This year the Foundation challenge is to move rapidly to implement these new directions.

Let me review in somewhat greater detail what I believe to be one of our most important accomplishments during the past year—our policy guidance on the engineering mission of the NSF over the next decade. All of us, including this committee, have spent considerable time in the last few years thinking through the role of NSF in engineering research and education. The Board brought several years of work to a successful conclusion this past summer. I believe the new directions will be strongly supported by the engineering community.

Engineering and manufacturing processes have been transformed by the introduction of computers, telecommunications, and information management and modern materials engineering as well into every phase of the industrial environment for engineering and manufacturing.

Indeed, as I have testified before this committee in the past, I believe that, in the competition that our industry faces with Japanese industry, it is their skill at manufacturing technology and at the rapid translation of development and research work into manufacturing that is their principal strength. This function must be provided by the engineers of this country, and it is our conviction that the educational enterprise has a very important responsibility to help improve the capability of this Nation to be economically effective and make best use of this leading science that we have.

So the Board concluded that, to meet the challenge, the National Science Foundation should expand and alter its traditional role in support of engineering sciences at academic institutions, and that specifically takes four forms.

First, NSF should not only continue to support the kind of work the Foundation has for years supported but provide increased support for the engineering sciences, including a number of areas where little support is now provided.

Second, computers are making a major change in engineering, and we should promote the appropriate use of computers both in education and in research and attempt to increase the participation in advancing computer engineering and other areas fundamental to computer design and implementation. I emphasize that this is not at the expense of computer science, but it is another important aspect of the computer phenomenon that really is engineering.

Third, NSF should increase its support for research, education and training and the transfer of research and technology between academia and industry in a variety of areas, including engineering processes, materials processing and manufacturing engineering.

It is these areas of systems oriented engineering that are of immediate value to every industrial operation that wants to be modern, whether it is a company that engages in high-tech advanced research or whether it is simply a company that must be on the competitive leading edge in quality and in cost, and I believe that this area, this new dimension to the NSF's work in engineering, will not only meet a very strong response among the leading engineering innovators in our universities but will also make our universities of much greater value to this enormous middle range of important corporations in America that are not substantially coupled into the research enterprise.

Fourth, NSF should strengthen the base of academic engineering by encouraging faculty development and growth, providing suitable implementation and facilities and improving educational and training methods and materials where needed. There are large parts of the engineering scene that call really for an educational investment at the graduate level and large numbers of universities are very eager to take on that task. These changed directions in both engineering research and education will develop over several years.

We also anticipate that private industry will be providing additional support for these directions as the universities begin to embark on them. If successful, the Foundation can help our engineering schools produce graduates who are both more effective in research and better trained to enhance the Nation's productivity and competitiveness. I am excited at this prospect and so is the Board, which is unanimous on this policy and urge you to help us pursue this opportunity.

In conclusion, I want to touch on a proposed amendment to the NSF Act that is being submitted to you in the draft authorization bill at the request of the Board. This amendment would treble the maximum dollar amount of awards for which the Board is permitted by law to delegate approval authority to the Director, increasing it from the current level of $2 million in total or $500,000 in any 1 year to $6 million in total or $1.5 million in any 1 year.

We request this change to reflect the inflation rate since 1968, the time at which the existing provision was enacted. I want to be clear that the purpose of our request is not to exercise less oversight of Foundation programs but it is to exercise more effective oversight. By reducing the number of individual grants we are required by law to review in detail based on a dollar limit, we will have more time to review programs and projects based on other equally important criteria.

We will, for example, want to look in some depth at specific programs that are new initiatives or those that have special policy significance. So I urge that you approve this amendment when it is brought to you.

Mr. Chairman, during the past year the Board has dealt successfully with major issues that will have a significant impact on the nation's scientific and technological future. We have developed an important level of consensus on these issues, clearing the way for effective action. The Director has, with the support of the administration, moved expeditiously and strongly to implement these strategic directions for the National Science Foundation.

I would now like to turn to him for the conclusion of our testimony. Later I will be happy to respond to questions. Thank you.

[The prepared statement of Dr. Branscomb follows:]

STATEMENT OF
DR. LEWIS M. BRANSCOMB
CHAIRMAN, NATIONAL SCIENCE BOARD
BEFORE THE
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
OF THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
FEBRUARY 3, 1984

Mr. Chairman and Members of the Subcommittee,

I am Lewis M. Branscomb, Chairman of the National Science Board. It is my pleasure to appear before you today to discuss the authorization of the FY 1985 budget for the National Science Foundation.

I will discuss some of the Board's recent activities that bear on the strategy behind this budget, the priorities in it, and the policy issues that are attached to its implementation.

The President's 1985 budget contains important priorities in a number of areas of special National Science Board attention during the last two years. Let me focus especially on five areas: (1) industry-university research cooperation, (2) research in and access to scientific computing, (3) science in the international setting, (4) science and engineering education, and (5) the engineering mission of the NSF. The Committee has the documents and statements to which I will refer; we will be glad to provide copies to Committee members.

While I am going to focus on five policy areas, the most important issue in this budget is the investment we must make in scientific research to ensure that American science retains its leadership position in the world. Unless we keep the fundamental research enterprise vital and competitive, our other efforts to commit science more strongly to the goals of the Nation will not be effective.

Industry-University Research Relationships

The Board's annual report last year highlighted the growing importance to both universities and to industrial firms of industry-university research cooperation. The studies that lay behind that report have just been published and made available to you. They describe a dynamic situation with a rapid growth of scientific and engineering collaboration, driven by natural forces that will be good for both groups of institutions. The Foundation's early encouragement helped trigger this development and continues to nurture it. This year's budget includes a major focus on making our investments in the fields where university-industry relationships have the most immediate benefit to our economy -- namely, engineering, materials science, and computing.

Scientific Computing

Computers are driving a revolution in science. The Board has encouraged the Foundation to respond both to the need to enhance access by research scientists to large scale scientific computers and to support advanced research in new ideas for the design of high speed computers. Peter Lax, a Board member, brought these issues before the Board and headed a group sponsored by DOD and NSF that prepared the Report of the Panel on

Large-Scale Computing in Science and Engineering. This report presented the need for making advanced computing resources available to the research communities. The Director then organized a series of internal studies which the Board reviewed and endorsed. They have led to an initiative in this budget to upgrade the access by scientists and engineers to large-scale computing.

Science in the International Setting

In a 1982 policy statement the Board concluded that the nature of science required that its international dimension be considered an organic aspect of the scientific enterprise and be actively provided for in all Foundation programs. The Director recently reported to us on implementation steps he had taken and the strategies he had developed to achieve the Foundation's goal of advancing the Nation's scientific and engineering research through international cooperation. The Foundation's implementation of the policy of broad participation by all programs in international science should lead to more effective use of resources and a stronger role for the U.S. in international issues in which we have a stake. The Board, through its Committee on International Science, continues its support for the important role we see for the Foundation and its Director in international scientific activities.

Science and Engineering Education

The Commission on Precollege Education in Mathematics, Science and Technology was established by the National Science Board and completed its work last September. Our expectations for this Commission were high and we were not disappointed. This extraordinarily capable and hard-working group of people produced a report that will provide the framework for action for years to come. In its resolution accepting the report, the Board strongly endorsed the Commission's view that the rebuilding of American educational superiority in mathematics, science, and technology is essential to the country and must be achieved through the efforts of state and local governments and local communities, stimulated and assisted by Federal leadership that makes educational goals a national priority and provides support for new approaches to mathematics, science, and technology education.

Based on the work of the Commission and the Board's implementation policy we have defined a role for the Foundation that represents a very small fraction of the national investment but a potentially very influential role in the quality of mathematics and science education. This year the Foundation must move rapidly to implement these new directions.

The Engineering Mission of the NSF

Let me review in somewhat greater detail what I believe to be one of our most important accomplishments during the past year -- our policy guidance on the engineering mission of the NSF over the next decade. We have all -- including this Committee -- spent considerable time in the past few years thinking through the role of NSF in engineering research and education. The Board brought several years work to a successful conclusion this past summer. I believe the new directions will be strongly supported by the engineering community.

Engineering and manufacturing processes have been transformed by the introduction of computers, telecommunications, and information management into every phase of the industrial environment for engineering and manufacturing. Engineering education and research capabilities in our universities must respond and adjust -- a demanding task. The Board concluded that to meet the challenge to the Nation's engineering strength and, derivatively, to its economy and security, the National Science Foundation should expand and alter its traditional role in support of engineering sciences at academic institutions. Specifically:

(1) NSF should provide increased support for the engineering sciences, including a number of areas where little support is now provided;

(2) NSF should promote the appropriate use of computers in engineering education and research, address problems of availability and accessibility of software and hardware, and increase its participation in advancing computer engineering and other areas fundamental to computer design and implementation;

(3) NSF should increase its support for research, education and training, and transfer of knowledge and technology between academe and industry in a variety of areas including engineering processes, materials processing, and manufacturing engineering;

(4) NSF should strengthen the base of academic engineering by encouraging faculty development and growth, providing suitable instrumentation and facilities, and improving educational and training methods and materials where needed.

These changed directions in NSF's engineering research and education programs will develop over the next few years. We also expect extra support from private industry for these directions. If successful, the Foundation can help our engineering schools produce graduates who are both more effective in research and better trained to enhance the Nation's productivity and competitiveness. I am excited at the prospect and urge you to help us pursue this opportunity.

NSF Act Amendment

Finally, I will touch on a proposed amendment to the NSF Act which has been submitted to you at the request of the Board. The amendment would treble the maximum dollar amount of awards for which the Board may delegate approval authority to the Director from $2 million in total or $500 thousand in any one year to $6 million in total or $1.5 million in any one year. We request this change to reflect inflation since 1968, the time at which the existing provision was enacted. I want to be clear that the purpose of our request is not to exercise less oversight of Foundation programs but to exercise more effective oversight. By reducing the number of individual grants we are required to review based on a dollar limit, we will have more time to review programs and projects based on other equally important criteria. We will, for example, want to look in some depth at programs that are new initiatives or those that have special policy significance. I urge that you approve this amendment.

Mr. Chairman, during the past year the Board has dealt successfully with major issues that will have a significant impact on the Nation's scientific and technological future. We have developed an important level of consensus on these issues, clearing the way for effective action. The Director has, with the support of the Administration, moved expeditiously and strongly to implement these strategic directions for the National Science Foundation. I would now like to turn to him for the conclusion of our testimony. Later I will be happy to respond to questions. Thank you.

Mr. **Walgren**. Thank you, Dr. Branscomb.

Dr. Knapp?

Dr. **Knapp**. Mr. Chairman, policy statements of the National Science Board, which Dr. Branscomb has described, have influenced this budget in many ways. I will touch on many of them in my comments this morning and in my further testimony before this committee next week. I would like to start today with a few examples of exciting opportunities in today's science. These opportunities touch on some of the most basic questions which scientists have asked. They exist today because of solid accomplishments made possible by the Foundation's support of excellence in research and excellence in people.

Among the enduring questions to which we constantly return are those concerning the structure of the universe, the fundamental nature of matter, and the nature of life. On each of these we are now ready to make new progress.

To help astronomers understand the structure of the universe, the 1985 budget requests funds to begin construction of the very long baseline array [VLBA] radio telescope. The VLBA is the most highly rated major new project in ground-based astronomy recommended by the 1982 report of the Astronomy Survey Committee. This array will produce radio images capable of resolving features down to 0.3 milli-arc seconds, or about the size of a dime in New York as seen from Los Angeles. That degree of resolution is 1,000 times better than that of any existing telescope. It will yield tremendously improved images of many astronomical objects now perceived dimly or not at all.

Construction of the VLBA will require approximately 4 years. The system will be made up of antennas located throughout the United States, from Hawaii to Puerto Rico, operating as a single unit with each antenna controlled from a main operations center. Although the VLBA will provide a tremendous advance in terms of scientific output, its design is based on proven concepts and instrumentation. As is the case with all major facilities supported by the foundation, the VLBA will be available to qualified scientists throughout the Nation.

Scientists have sought for centuries to understand the most fundamental nature of matter. Some of the most significant work of this nature is underway today at the Cornell Electron Storage Ring [CESR]. Since it began operations in 1980, CESR has been singularly successful in studies in elementary particle physics. This work has now reached the point where the CESR facility should be substantially upgraded.

The 1985 budget requests funds for the first phase of this effort, in accordance with the strong recommendation of the High Energy Physics Advisory Panel. The planned improvements will result in an increase in the particle detection rate by a factor of nearly 1,000 and will assure that CESR will remain, through the rest of the decade, the leading facility in the world for the study of the structure of matter in this energy range.

The proposed budget will support new research on the nature of life through an emphasis on the chemistry of life processes. We are now in a position to advance our understanding of life processes, because increasingly sensitive analytical techniques allow us to probe the details of chemical change in systems of extreme molecular complexity.

Recent advances in molecular biology and biochemistry, such as the chemical synthesis of artificial genes, make it abundantly evident that we are at the threshold of major advances in understanding life processes. The ultimate understanding of life processes depends on their examination at the molecular level by the techniques of chemistry.

Rapid progress is being made toward understanding enzyme action, the immune response, gene regulation, nerve transmission, and membrane function. Multidisciplinary research, emphasizing the cooperation of chemists and biologists, will allow the rapid development of knowledge essential for biotechnology related to medicine and agriculture.

I would also like to comment on several other areas which receive special emphasis in next year's budget.

Dr. Branscomb has already highlighted the National Science Board's policy resolution on engineering research and education. This budget begins to implement that resolution in two ways.

A year ago, with strong support from the National Academy of Engineering, the foundation initiated the Presidential Young Investigators Program. This program, which receives matching funds from industry, provides up to 5 years of research support for some of the Nation's most outstanding young science and engineering faculty. Half of these awards have been made to young engineers.

We hope in this way to make academic careers more attractive to talented young engineers and thus help the Nation's engineering schools to fill some of the 2,000 faculty vacancies that have existed for several years. In 1985 we expect to make an additional 200 new awards. About half of them will continue to go to engineering faculty.

A second important initiative this year will provide support to upgrade engineering programs within universities and colleges. Special emphasis will be placed on establishing research centers at universities in such areas as computer-based manufacturing systems, biotechnology processing systems, and new approaches to telecommunications. Heavy stress will be laid on cooperation with industry. In the first year this program will require $10 million.

Social science is another research area which this committee has strongly supported. This area receives strong emphasis in our 1985 budget, with a very substantial increase, nearly 24 percent, in the political and policy science area for support of data bases. Further progress in these sciences depends heavily on these data bases.

Ocean drilling: We have discussed this with you extensively in recent years. A year ago I convened a special advisory group to help us choose among several options, and I am happy to report that this program is now proceeding smoothly. A new drillship will be leased and converted for scientific drilling during the current fiscal year and will begin operations in 1985. It is especially pleasing to note that in 1985 we expect $10 million from our foreign partners to help support the ship's operating costs.

Mr. Chairman, last year I discussed with you a new management plan for the Foundation. That plan proposed to transfer as much responsibility for special NSF programs to the main research directorates as was feasible. Several internal studies were undertaken to establish the proper distribution of responsibilities to accomplish these goals, and I am happy to report that the final plan is now in place.

Among other decisions, we have left the congressionally approved programs for women, minorities, and the handicapped centrally administered, but have initiated new expansions of aid to these groups within the research directorates. Additionally, the programs for research at primarily undergraduate institutions are handled almost exclusively in the research directorates.

On international cooperative science there is a joint responsibility. Our international programs division is responsible for workshops, seminars, and the foreign policy aspects of such research, while the research directorates are responsible for the scientific content. The expansion of such research, when it is in the best interests of the United States, is the joint responsibility of both organizations.

I would like to close with a note of thanks to this committee for its support of the Foundation's peer review process. As the committee is aware, the Foundation's research and fellowship awards are made on the basis of a highly competitive process, which is absolutely essential to the maintenance of excellence. The key to this is that proposals are judged on the basis of merit by scientists and engineers working in the same fields. The peer review process is our principal means of recognizing and responding to scientific opportunities and for maintaining a high standard of quality. The support of that process by this committee has been essential to the health of the Nation's science and technology enterprise. We deeply appreciate your support of the peer review process and trust that support will continue.

Mr. Chairman, this concludes my prepared oral testimony. When I appear before you next Thursday, I will discuss in detail our initiative in supercomputers, our concern with research instrumentation, and our program in science education. I have submitted the highlights of the fiscal year 1985 budget request for the record and will be pleased to answer any questions that you and your colleagues may have.

[The prepared statement of Dr. Knapp and "Highlights of the Fiscal Year 1985 Request" follow:]

National
Science
Foundation

STATEMENT OF

DR. EDWARD A. KNAPP

DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

FEBRUARY 3, 1984

Mr. Chairman, Members of the Committee --

It is a pleasure to be with you today for the first of two days of hearings on the Administration's FY 1985 budget request for the National Science Foundation. The Administration has requested a strong, well-balanced budget. It will build upon the strong budget that the Administration requested and the Congress approved for the current fiscal year.

Realizing the most critical goals of our Nation -- sustained economic growth; enhanced national security; and improved quality of life -- will depend critically on how well we develop and apply new scientific and engineering knowledge. And our ability to develop and apply that knowledge will depend on persuading our most talented young people to pursue careers in science and engineering. Meeting these two needs -- the need for knowledge and the need for people who can use it -- is the mission of the National Science Foundation. Before discussing further the current budget request, I would like to take just a few minutes to show you a short film that provides some examples of how we go about meeting these needs.

Mr. Chairman, in view of the continuing support and encouragement of this Committee, I believe you will be pleased to know that the Administration's FY 1985 budget request for the Foundation totals just over one and a half billion dollars. This represents an increase of almost $182 million, or 13.7 percent above the FY 1984 Current Plan. The request includes one billion, 308 million dollars for Research and Related Activities, $115 million for the U.S. Antarctic Program, $75.7 million for Science and Engineering Education, and $2.8 million for Special Foreign Currency.

The activities which these funds will support are selected through a complex planning process which begins with consideration of major policy issues by the National Science Board. The Board's policy statements then inform our long range planning process, and are a major factor in selecting specific budget priorities. I am especially pleased that Dr. Lewis Branscomb, Chairman of the National Science Board, is here today to highlight five major policy issues which the Board has dealt with in the recent past.

Mr. Chairman, the policy statements of the National Science Board which Dr. Branscomb has described have influenced this budget in many ways. I will touch on many of them in my comments this morning and in my further testimony before this Committee next week. I would like to start today with a few examples of exciting opportunities in today's science. These opportunities touch on some of the most basic questions which scientists have asked. They exist today because of solid accomplishments made possible by the Foundation's support of excellence in research and in people.

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Mr. Chairman, this concludes my prepared oral testimony. I have submitted the highlights of the FY 1985 budget request for the record, and will be pleased to answer any questions that you and your colleagues may have.

HIGHLIGHTS OF THE FY 1985 REQUEST

MATHEMATICAL AND PHYSICAL SCIENCES (MPS)

The FY 1985 Budget Request for MPS is $416.7 million. This represents an increase of $57.9 million, or 16.1 percent, over the FY 1984 Current Plan. This increase will improve all aspects of NSF support for research in these disciplines. Mathematical Sciences increases by $9.0 million to $50.5 million. Computer Research increases by $ 5.5 million to $39.35 million. Physics increases by $15.9 million to $121.8 million. Chemistry increases by $12.1 million to $92.1 million. Materials Research increases by $15.5 million to $113.0 million. These increases in the subactivities affect the major components of all programs as follows:

Research Projects -- Scientific Research Project Support (SRPS) is increased $30.7 million, or 13.1 percent, to a total of $265.3 million. Included in that amount is instrumentation totaling $31.4 million.

- In the mathematical sciences, continued substantial improvement is made in the support of graduate and postdoctoral students, including the Mathematical Sciences Postdoctoral Fellowship Program. Increased support is also provided for research activities in computational mathematics and statistics and for access to appropriate computational facilities.

- Research project support in computer research is strengthened to respond to new research opportunities generated by the establishment of the Coordinated Experimental Research program. Increased participation by graduate students is stressed throughout.

- The efforts to revitalize university physics research are continued by providing new research instrumentation and improved computing capabilities to active research groups and increasing support for postdoctoral scientists and graduate research assistants. An important major focus continues to be the provision of new incentives and research opportunities for young researchers.

- The Nation's academic research effort in chemistry is further strengthened by providing new and expanded research opportunities in areas presenting significant promise for rapid advancement, with special emphasis on the chemistry of life processes as recommended by the Committee to Survey the Chemical Sciences of the National Academy of Sciences. Increased support is targeted on the most creative established investigators and on young investigators.

- Major emphasis in materials research is on strengthening the training of future materials scientists and engineers, particularly in technologically important areas such as electronic materials, ceramics, and polymers. Enhanced support is provided for instrumentation, associated technical support, and necessary materials and supplies. The number of multi-investigator or multi-disciplinary projects supported is increased, particularly in the basic engineering areas of materials research.

Special Equipment Programs -- Most subactivities provide support through formal or informal programs for the acquisition of research instrumentation and equipment for group or departmental use. Support for special equipment is increased by $3.9 million, or 19.1 percent, to a total of $24.3 million.

University Laboratories--Support for research, operations, and instrumentation at university laboratories in computer research, physics, and materials research is increased by $10.1 million, or 18.5 percent, to a total of $64.8 million. Included are the experimental computer research facilities, a number of nuclear physics laboratories, and the Materials Research Laboratories.

National User Facilities -- Support for national user facilities is increased by $5.8 million, or 12.6 percent, to a total of $52.0 million. Included are the Mathematical Sciences and Theoretical Physics Institutes, the Cornell Electron Storage Ring, the Michigan State University Superconducting Cyclotron, Synchrotron Radiation facilities, and the National Magnet Laboratory.

Advanced Scientific Computing -- MPS support for the Foundation-wide initiative on advanced scientific computing is increased by $7.3 million to a total of $10.3 million. This support contributes to the establishment of university supercomputer facilities, associated networks, and local facilities.

ENGINEERING (ENG)

The FY 1985 Budget Request for this activity is $147.1 million. This represents an increase of $26.4 million, or 22 percent over the FY 1984 Current Plan of $120.7 million. Within this amount:

- Electrical, Computer, and Systems Engineering is increased by $8.7 million from $36.0 million to $44.7 million with added emphasis in microstructure fabrication research, integrated optical devices, automated design, microsensors, and robotics to aid the handicapped, and optimization methods for production scheduling in industrial processes.
- Chemical and Process Engineering is increased by $5.9 million from $26.6 million to $32.5 million which provides for efforts in biotechnology, novel processing techniques, catalytic reaction engineering, microcontamination control, and plasma-chemical processing.

- Civil and Environmental Engineering is increased by $6.0 million from $33.8 million to $39.8 million with special support in coastal and ocean engineering, problems of repair, retrofit, and rehabilitation of parts of the public infrastructure, and upgrading and modernization of experimental facilities used in earthquake engineering.

- Mechanical Engineering is increased by $5.7 million from $24.6 million to $30.3 million with added emphasis in thermal systems, tribology, biomechanics and robotics/automated manufacturing.

- Advanced Scientific Computing increased by $3.5 million from $1.5 million to $5 million and reflects engineering efforts devoted to the Foundation-wide initiative which began in FY 1984 to provide access to advanced computer facilities for researchers from all disciplines.

- Centers for Cross-Disciplinary Research in Engineering is a $10 million initiative designed to support the development of centers, which will perform cross-disciplinary research on problems of importance to industry while simultaneously educating graduate and undergraduate students in engineering practice.

ASTRONOMICAL, ATMOSPHERIC, EARTH, AND OCEAN SCIENCES (AAEO)

The FY 1985 Budget Request is for $373.5 million, an increase of $43.5 million or 13.2 percent over the FY 1984 Current Plan of $330.0 million. The increase is applied as follows:

- Astronomy is increased $15.2 million from $78.2 million to $93.4 million. This increase allows the subactivity to carry out the most important recommendations of the report of the Astronomy Survey Committee of the National Academy of Sciences. This includes the first-phase of a "major new program," the acquisition of the Very Long Baseline Array (VLBA) that requires most of the increase.

- Atmospheric Sciences is increased $9.2 million from $89.3 million to $98.5 million. This increase provides for the first-phase acquisition of the Advanced Vector Computer (AVC) to be based at the National Center for Atmospheric Research and allows for continued payments towards the mass storage system. Project support increases in all subdisciplines, particularly in atmospheric chemistry. The Global Atmospheric Research Program, now well into the analysis of data analysis, continues to phase down.

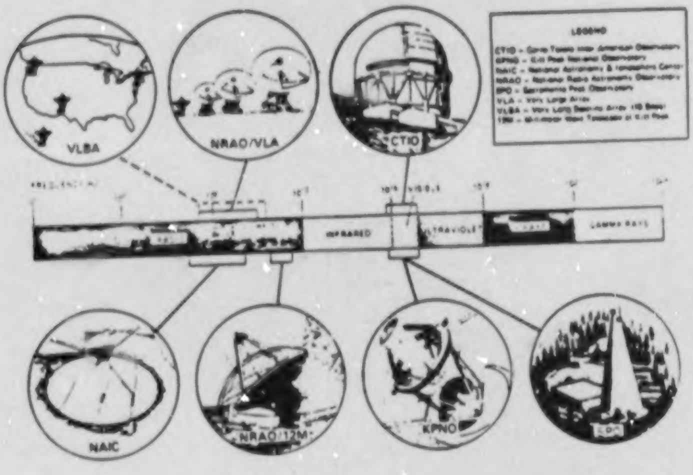
- Earth Sciences is increased $7.1 million from $41.5 million to $48.6 million, which allows for major upgrading of instrumentation and a major research thrust on the chemistry, structure, and geologic history of the continental lithosphere as recommended by the National Academy of Sciences report, "Opportunities for Research in the Geological Sciences, 1983." The latter will include continued continental reflection profiling (COCORP) operations, and preliminary site surveys prerequisite to deep continental drilling.

- Ocean Sciences is increased $11.2 million from $113.7 million to $124.9 million with emphasis on studies of the ocean floor. Increased equipment support is provided through project grants. Maintenance and upgrading of shipboard scientific equipment is also a priority. The Ocean Drilling Program now included here, will commence the first year of an international drilling program using a large, modern drillship.

- Arctic Research is increased $0.6 million from $7.4 million to $8.0 million. Increases are provided particularly for atmospheric, biological, and earth sciences research.

- Advanced Scientific Computing, which is separate from but coordinated with the NCAR Advanced Vector Computer acquisition, will provide increased access to advanced computers as well as local facilities to take advantage of the contributions that advanced computer use can make to the AAEO disciplines. In FY 1985, $2.4 million is provided for this initiative.

SPECTRUM COVERAGE OF TELESCOPES AT NATIONAL ASTRONOMY CENTERS

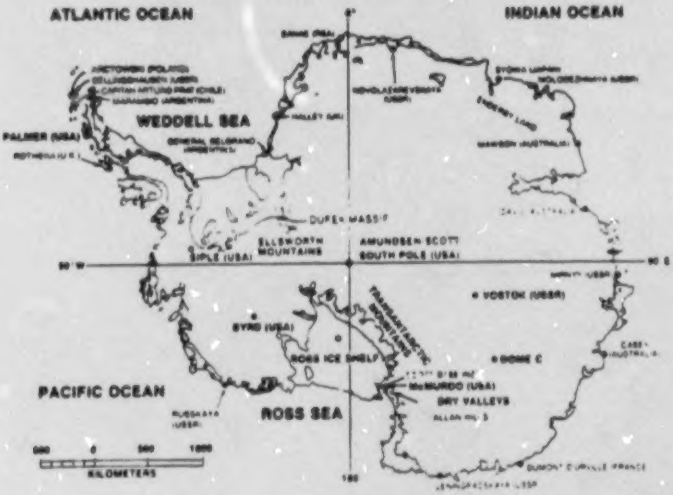


U.S. ANTARCTIC PROGRAM (USAP)

The FY 1985 Budget Request is a 12.3 percent increase over the FY 1984 Current Plan. The increase of $12.6 million from $102.5 million to $115.1 million is required for expenses in the following categories:

- An amount of $6.0 million is included for the first time to reimburse the Department of Defense (DOD) for military retirement costs. There will be a corresponding decrease in the DOD FY 1985 budget request for military retirement costs, therefore, this adjustment does not result in an increase in the total Federal budget.
- There is a $0.8 million increase in the U.S. Antarctic Research Program to a total of $11.0 million, which will provide for an increase in the number of research awards and new initiatives in glaciology and oceanography.
- The remainder of the increase, $5.8 million, will be used by the Operations Support Program to offset across-the-board price increases and continue the equipment procurement and facilities upgrading and maintenance that has been deferred in prior years.

ANTARCTICA: selected stations and physical features.


ATLANTIC OCEAN
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WEDDELL SEA
PALMER (USA)
ROTHERA (U.K.)
GENERAL BELGRANO (ARGENTINA)
HALLEY (UK)
NOVOLAZAREVSKAYA (USSR)
SYOWA (JAPAN)
MOLODEZHNAYA (USSR)
ENDERBY LAND
MAWSON (AUSTRALIA)
DAVIS (AUSTRALIA)
DUFEK MASSIF
ELLSWORTH MOUNTAINS
SIPLE (USA)
AMUNDSEN SCOTT
SOUTH POLE (USA)
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90° E
MIRNYY (USSR)
VOSTOK (USSR)
BYRD (USA)
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SCOTT BASE NZ
McMURDO (USA)
DRY VALLEYS
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LENINGRADSKAYA (USSR)

BIOLOGICAL, BEHAVIORAL, AND SOCIAL SCIENCES (BBS)

The FY 1985 Budget Request of $253.1 million is an increase of $28.4 million or 12.7 percent above the FY 1984 Current Plan. Within this amount:

- Physiology, Cellular, and Molecular Biology is increased $14.3 million, from $102.1 million to $116.4 million. The increase will allow a continued emphasis in the plant sciences to advance the understanding of plants through application of both contemporary molecular and cellular approaches and instrumentation technologies. Additional emphasis will be placed on research using genetic methods to examine fundamental biological questions and on the chemistry of biological processes. Continued attention will be paid to providing funds for research instrumentation and research resources.

- Biotic Systems and Resources is increased by $6.5 million from $53.4 million to $59.9 million. The increase will allow a continued emphasis in the plant sciences, including research on the role of plant toxins in controlling damage by insects, and on plant adaptation to nutrient limitations. Emphasis will be placed on augmenting awards to permit use of instrumentation and materials essential for the application of molecular genetic techniques to studies of systematics and population biology. The program to refurbish marine biology laboratories will be continued.

- Behavioral and Neural Sciences is increased $3.8 million from $38.5 million to $42.3 million. In the neurosciences a $3.0 million increase will be used primarily for instrumentation and increasing award sizes for the most promising projects. The $0.8 million increase in cognitive science and anthropology will permit increased attention to such important research areas as human origins, the learning process, and studies on the development of cognitive capacities, including language.

- Social and Economic Science is increased $3.4 million from $24.6 million to $28.0 million. The increase provides for the extension of key socioeconomic data resources and a strengthening of related methodological and theoretical research.

- Information Science and Technology is increased $0.5 million from $6.1 million to $6.6 million. The additional funds will allow continued support for research in selected areas of information technology and information impact which will generate fundamental knowledge bearing directly on current advances in electronic and computing machinery.

- Advanced Scientific Computing will be increased to $2.4 million to provide for communications links and network facilities for user access to these resources as well as support for local user costs, such as software, technical support, and auxiliary equipment. The Foundation-wide initiative builds upon activities begun in FY 1984.

SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS (STIA)

The Scientific, Technological, and International Affairs (STIA) activity carries out essential Foundation responsibilities that cut across scientific disciplines and provide unique services to the scientific and engineering community. Because STIA provides the Foundation with a broad window to the diverse elements of the U.S. scientific and engineering enterprise, it advances the Foundation's leadership role with regard to the improved functioning of that enterprise, provides better understanding of the use of science and technology by different sectors of society, and enhances the returns from the national investment in research. The FY 1985 Budget Request of $46.9 million is an increase of $6.1 million or 14.9 percent above the FY 1984 Current Plan of $40.8 million. The increases are applied as follows:

- Industrial Science and Technological Innovation (ISTI) increases from $17.6 million to $23.4 million. The entire increase of $5.8 million is applicable to the NSF Small Business Innovation Research (SBIR) program and complies with the mandated percentage required by P.L. 97-219, the Small Business Innovation Development Act of 1982. It will provide for: continuation funding of about 30 Phase II awards started in FY 1984; increase in the size of an estimated 110 Phase I awards from $35,000 to $40,000; and award of approximately 40 new Phase II projects in FY 1985. There are no changes in other ISTI programs involving industry/university cooperative research projects, research centers, and productivity improvement research.

- International Cooperative Scientific Activities remains at the FY 1984 level of $5.5 million. This amount will provide support for U.S. participation in seminars, workshops, and short-term scientific visits abroad. An estimated 900 U.S. scientists and engineers will participate in these international activities. An additional $6.8 million for support of international cooperative research projects and $1.5 million for the Indo-U.S. Science and Technology Initiative have been earmarked in other NSF budget activities. The international subactivity continues to coordinate and manage bilateral cooperative agreements and the Indo-U.S. Science and Technology Initiative. Special emphasis will also be given during FY 1985 to maintenance of programs with China, Eastern Europe, Western Europe, Sub-Saharan Africa, and Latin America, as well as continuation of U.S. participation in international scientific organizations.

- Policy Research and Analysis increases by $100,000 for a total of $4.7 million in FY 1985. The increase is focused in the Technology and Resource Policy program element to expand studies and research on the impact of telecommunications, computers, and information networks on Federal policies dealing with science, technology, and natural resources.

- Science Resources Studies increases by $100,000 for a total of $4.7 million in FY 1985. The FY 1985 program maintains the science resources data base through continuation of the periodic survey program at approximately its current level of effort. The additional funds will permit the expansion of regular surveys of industrial firms to generate systematic data on U.S. innovative activities, such as the number of new products introduced each year. This effort will build on feasibility studies carried out in FY 1982 and 1983. Support for a survey of recent and senior science and engineering faculty is also included.

- o Research Initiation and Improvement increases by $77,670 for a total of $9.0 million in FY 1985. The increase will permit the initiation of a new program, Research Opportunities for Women, at a level of $0.5 million. Program elements to be funded entirely by discipline-oriented research activities will increase by a net amount of $15.0 million over the $53.2 million level provided in FY 1984. Increases will go to: Presidential Young Investigators Research Awards--$11.9 million (from $11.9 million to $23.8 million); Support for Predominantly Undergraduate Institutions--$5.6 million (from $36.8 million to $42.4 million.) The Experimental Program to Stimulate Competitive Research, supported at $2.5 million in FY 1984, is discontinued in FY 1985 consistent with its original plans and objectives. NSF Planning and Evaluation remains constant in FY 1985 at $2.0 million.

The disciplinary research activities have earmarked a total of $80.7 million for programs to be coordinated by STIA as shown below.

PROGRAMS COORDINATED BY STIA THAT RECEIVE PARTIAL OR TOTAL FUNDING WITHIN THE DISCIPLINE-ORIENTED RESEARCH ACTIVITIES IN FY 1985
(Millions of Dollars)

Program	*STIA*	*Funding Within Research Activities*	*Total*
International Cooperative Research Activities	$ 5.0	$ 6.8	$11.8
Indo-U.S. Science and Technology Initiative	$ 0.5	$ 1.5	$ 2.0
Industry/University Cooperative Research Programs	$ 7.0	$ 7.0	$14.0
Presidential Young Investigators Research Awards	$ —0—	$23.8	$23.8
Support for Predominantly Undergraduate Institutions	$ 2.8	$39.6	$42.4
NSF Planning and Evaluation	$ —0—	$ 2.0	$ 2.0
Total	**$15.3**	**$80.7**	**$96.0**

SCIENCE AND ENGINEERING EDUCATION (SEE)

The FY 1985 Budget Request for SEE is $75.7 million, an increase of $0.7 million from the FY 1984 New Obligation Authority of $75.0 million. The FY 1985 support will be distributed as follows:

- Graduate Research Fellowships ($21.0 million). This represents an increase of $0.7 million or 3.4 percent above the FY 1984 total of $20.3 million and will support 550 new fellowships for an overall total of approximately 1,550 fellowship offers. The annual stipend for graduate fellows increases from $8,100 to $9,000 and the annual cost-of-education allowance will be $4,900, the same as in FY 1984.

- Precollege Science and Mathematics Education ($54.7 million). This amount is the same as the FY 1984 New Obligational Authority and will provide support for teacher development and incentives, new instructional materials, special studies to gain a better understanding of precollege science education in the U.S., research in teaching and learning, informal science education, and activities to publicize and disseminate information about highly successful programs and outstanding research efforts. The requested FY 1985 level is approximately double the FY 1980 level for this subactivity.

PROGRAM DEVELOPMENT AND MANAGEMENT (PD&M)

The Program Development and Management Activity provides resources for the effective management of NSF.

The FY 1985 Budget Request for the PD&M activity is $77.9 million, which represents an increase of $4.3 million or 6.5 percent from the FY 1984 Current Plan of $66.6 million. The number of full-time equivalent employment is 1,194, the same level as the FY 1984 Current Plan.

Within the amount for FY 1985:

- Personnel compensation and benefits will be funded at $51.2 million, an increase of $.91 million or 1.8 percent above the FY 1984 Current Plan level. The additional amount will annualize the costs of the pay increase effective January 1984.

- Travel of staff, proposal reviewers, panelist and advisors is increased by $.48 million or 16 percent. The increase will offset some of the rise in fare costs since the Foundation's overall travel limitation was last raised two years ago and provide limited real growth in the amount of travel which can be performed for staff site visits and program administration.

- Funding for planned data processing equipment purchases is increased to $1.05 million which will permit enhancement of the Foundation's data processing capability consistent with the established long-range plan.

- All other PD&M costs items will be increased by a total of $1.9 million, or 14.8 percent and will fund required office space alterations, assessed communications equipment purchase charges by the General Services Administration, cost increases for employee training, contract software development, increased usage of supplies and other contractual services required for the day-to-day operations of the Foundation.

Mr. Walgren. Well, thank you very much, Dr. Knapp, for that presentation. I think we all are very pleased with the directions that these proposals go in, and with the developments in the Foundation over the last 2 years in any event.

I think, in particular, the role of the National Science Foundation Board—the National Science Board has been a good leavening element in the chemistry that has gone on in policy formation over the years. Seeing the emphasis that the Board has given both to education as a major problem and to the engineering problem as a major problem, and the timeliness of reports in that area and the responsiveness of the Foundation to those reports, certainly is very reassuring, at least from this perspective, and I want to personally congratulate both of you on the working relationship that you obviously have.

I would like to ask each of you about the relationship between the Board and the Foundation. As I understand it, the charter gives you kind of joint responsibilities, almost mentioning both entities in the same breath, as it were, with respect to responsibility for policy. I would like to ask an open-ended question to describe the positive things you see in that relationship and then your frustrations with it.

Could I ask each of you that question, starting with Dr. Knapp?

Dr. Knapp. Yes; I would be glad to respond to that. I must say that, in my almost 2 years now with the Foundation, I have been extremely pleased with the relationship between the Foundation, myself, and the rest of the management of the National Science Foundation and the National Science Board. I think the relationship is very smooth, very positive, and very—and positively reinforcing.

The way policy issues are discussed in the Board is, I think, illustrated perhaps by this engineering issue which we have come forward with, I think, a very nice program for engineering for the National Science Foundation for 1985. It is really a product of the Foundation's internal management, the Engineering directorate, particularly.

The National Science Board did a major study of engineering for its June meeting last year in which we devoted an entire meeting to policy issues, and engineering was the major issue studied, studied in a great deal of depth. In addition, the Board and the Foundation have had excellent relationships with the National Academy of Engineering and many of the engineering societies in developing the ideas that have gone into this change in emphasis and directions for the Foundation in engineering, and those interactions have been extremely positive, too.

If there is anything about the relationship between the Foundation's management and the Board which is awkward, it perhaps is addressed in the amendment that the Board is presenting to you for your consideration; that is, the Board perhaps gets a little bit taken up with looking at individual grants and has its time spent more looking at the details of individual grant requests than the overall policy issues. I think the Board could spend more time on policy.

I think the Board is convinced that the National Science Foundation management does a good job of administering the funds that are appropriated to it and would like to spend more time on general policy issues and perhaps a little less time on the individual grant mechanics.

With that, I will let Dr. Branscomb add comments.

Dr. **Branscomb**. It may seem a little immodest for a member of the Board to express a view that the Board is an essential element of the effectiveness of the Foundation, but I believe it to be, and I think, if there are tensions or frustrations, they are inherent in a very desirable situation that goes all the way back to the many years of debate in this Congress on formation of the Foundation in the first place.

You will recall that there were great debates about whether or not the Foundation should be structured as a, let me say, typical Government agency and managed in the traditional manner or whether, at the other extreme, the Government might establish something that looks rather more like the Ford Foundation or an independent foundation that simply received Government money.

President Truman, in my opinion quite wisely, did not accept the latter proposal, because he noted that, if public funds are being expended, he could not abrogate his responsibility to the Congress that they are properly spent and, therefore, he had to have a proper managerial relationship with the management of the Foundation in order to insure that. So we have a situation where the Director is both accountable to the Board for policy and accountable to the President for execution of the President's policy as well as the Board's policy.

The law, indeed, states that the Board, when it makes policy, is to do so in the context of the policies established by the Congress and the President. So we do not make our policy in a vacuum. We make it in the real world, with the President's intentions and policies and this Congress'. Therefore, we do not operate in the theoretical mode of a foundation that the Government funds but then turns loose.

I think science is too important to the well-being of our people and the investments we are making are too large to have it managed at an excessively long arm's length from those accountable to the people.

I would like to make one other observation, and that is that, illustrating it by this issue of when should we delegate or when should we not delegate to the Director the authority to make a grant, the Board has no independent authority to acquire resources for the Foundation to invest. We do work with the Director on the establishment of our priorities and our budget; the budget that we submit to the OMB every summer is always our joint budget.

In my memory, it has always been unanimous. That is our collective proposal, but, of course, the President has his responsibility to create a budget for the Nation and for the Congress, and that process has to operate in the real world of the way budgets are done, with the normal give and take, and so the outcome is not always precisely what the Board would like it to be.

On the other hand, the Board has a kind of negative authority; that is, it is charged by the Congress with approval of expenditure of the funds and, indeed, this particular statute in no way restricts the authority of the Board to exercise its accountability to the Congress for the making of grants.

What it restricts is our ability to delegate that responsibility, and so we have, in a sense, the anomaly that our authority is from a literal point of view rather a negative authority; that is, we must approve the expenditure of funds, and while that might seem a little anomalous, in my opinion, it is not; for the Foundation's guiding spirit is that it respond to the best opportunities that the hearts and minds of American scientists can generate.

The Foundation uses peer review; it uses the most able talents it can find in the most objective mechanism it can invent to choose among those opportunities, within the constraints of the budget as established, and invests, in research, research being a highly risky business, nevertheless capable of producing some astounding things.

Dr. Knapp mentioned two major facilities investments in our budget this year, and I notice that he referred to factors of 1,000 improvement in the ability to measure or to accomplish a scientific task. That is when science is working well, when, for a modest increment of a few percent in investment, you can get a factor of 1,000 in capability. That being the nature of science, it is the quality with which the Foundation works with the scientific community to produce those results that is the hallmark of our effectiveness. I think the Board plays a very important role, in some sense, as a kind of surrogate for peer review itself, being very diverse in the background of its members to insure that that process works, that the quality is there. By looking at quite specific grants, we gain the experience, not in the abstract in generality, but in actual cases through our committees of going through what goes into those grants.

The awkwardness of this particular arrangement is that the criterion by which we gain that experience is about at cutoff level and if we had more time, we might spend more time looking at grants in fields like social science where the amounts are quite small, where they rarely reach this level.

My last comment is that, in some press coverage of the Board's own introspection about its role, comments have been made to the effect that the Board is a very diverse group and perhaps one should be understanding of its limited ability to engage in a huge volume of broad-range policy research.

I will tell you that it is the diversity in this Board that makes it effective, for when all 24 members coming from very diverse scientific backgrounds, and diverse institutional backgrounds agree with conviction that this kind of very abstract theoretical science should be pursued or that kind of very pragmatic engineering education should be invested in, you have developed a surrogate for a consensus in the country that those things which have the support of the people can be done.

I think that is an important role for the Board. In that respect, I think the Board and the Foundation are very synergistic and work very effectively together.

Mr. WALGREN. Let me just ask one other question before recognizing the other members, and that is on this subject of the grant approval. Coming to it very new, I was pleased that the board has to review the grants that the director would allocate, or that the management of the Science Foundation was allocating.

Knowing politics to be what it is, and wanting to have the ultimate insulations of the decision making of these grants being based in science, it is nice to think of that review process being there. It does strike me that going up to $1,500,000 is a substantial grant authority to have in one direct chain of executive disposal, and I guess my question is how unmanagable problem really is it?

The criticism, as I understand it, has been that the board did nothing but process these evaluations of the grants and got so enmeshed in that they were not going to focus on larger policy development and consideration. Yet it does strike me that it is possible to have a committee structure which the Board could rely on in such and such a way that would at least maintain the overview of the grant in such a way that we would be satisfied no matter who the Director of the National Science Foundation was, or what pressures they came under from whatever sources, there was a neutral interposed judgment made.

Is that really unworkable?

Dr. **Branscomb**. Your understanding of how it ought to work is the way it does work and the current situation isn't unworkable.

Let me, in fact, describe how it works. The Board typically meets for a 2 day meeting each month. The Board has a programs committee which comprises half of its members; the other members being on a policy committee. They meet concurrently, typically. So we have a committee doing policy work, full time, while the other committee is doing the program activity.

That program activity spends perhaps 4 or 5 hours, say an afternoon, long afternoon, maybe 3 or 4 hours, looking at the grants that are coming before it, and normally we have been delegating to the director all of the authority for making grants each year.

At our main meeting, we give him that blanket delegation with the exception of the reserved area that is in the law.

The committee goes through those programs and then at the full Board meeting perhaps the next morning, a meeting open to the public, the committee chairman reports the results of the committee's deliberations to the full Board. There is an opportunity for discussion usually. I would guess—I don't have an exact percentage—I would guess, in 95 percent of the cases, the committee recommends the making of the grant with no changes whatever. Perhaps the percentage is higher than that. And the Board typically spends a maximum of 5 minutes on one of those grants after the committee members at the meeting have had the opportunity to convey their satisfaction in the sense that there is no controversy.

Occasionally, there is an issue that the committee feels deserves attention. I would guess that in the remaining 5 percent, and I would guess that, in 95 percent of those, the staff of the Foundation agrees that that is a reasonable concern and modifies the program right on the spot in some modest way or perhaps takes it back for a little more work and brings it to us the following month.

It is not a controversial process. The total activity in our Board meetings occupied with approval of such grants would represent, I would think, maybe an hour or two out of 2 days of work. The issue really is not that and, in fact, the programs committee activity, in my opinion, is the best way the Board members, who are part time and busy folks, learn from microcosmic examples of the details of how the peer review works. They get a chance to read the peer reviews and ask about the process, to concern themselves about the problems that the university grantees have in making these kinds of programs.

The problem is the one I cited before. We would like to exercise our stewardship in behalf of the Congress and the people in a way that is not defined by the dollar level. And while I will grant you we regard all expenditures of Government money as important, and $1.5 million as very important, we are dealing here with a $1.5 billion agency.

So the number of such projects is large, and if we could be a little more selective, some of these grants which support a continuation of existing institutional programs that we visit, we review them in other ways, we know about them, don't require that much attention, and if we could change the way we delegate the authority to cover our responsibilities a little more easily.

Let me just finally say that we are a little reluctant to do what would be an obvious strategem, which we could do without a change in the authority, which is simply to decide that for some of these projects we really wouldn't—the committee wouldn't spend 45 minutes in detailed questioning, that it would accept a much more superficial kind of report, and simply pass that on through the Board. We could operate that way.

The tradition of the Board has not been to do that, it is any project that they are going to look at and make the decision on their own, to approve, they should look at with care to be sure that we do see with care a reasonable amount of the Foundation's work.

Mr. **Walgren**. If I can understand that, the benefit that you see in this is that you want to exercise your role in program review differently, and even though this present strategem does not consume an inordinate amount of time, or even though it is certainly workable, in your view, you feel that there is unique benefit to be gained from not being involved or not having to be involved on that level?

Dr. **Branscomb**. I would anticipate, we do spend a significant fraction of—what I have described is a significant fraction of the work, it is not a majority of our work. I think we would continue to devote as much time as we now do to the examination of programs at a level of substantial detail. I think what we would do is change the distribution of our attention over the activities of the Foundation somewhat, and I think that would be beneficial.

I think the Board would end up better informed about the details of how the Foundation operates and all its activities and we would soften what has been an inevitable bias of our attention, not necessarily our enthusiasm, between the large programs that represent an aggregation of effort and the research of individual scientists.

Mr. **Walgren**. Thank you.

Mr. Skeen.

Mr. **Skeen**. Thank you, Mr. Chairman.

Dr. Knapp and Dr. Branscomb, it is a real pleasure to hear a dissertation on policy development and how it is being handled from someone other than members of the world's second oldest profession, the legal fraternity. But it is good to hear scientists talking about making scientific policy.

Dr. Knapp, we are pleased to see the inclusion in the budget of the VLBA request, the very long base line telescope. Could you tell me when—if the request is honored, if we can get through this thing—when you plan construction on that particular phase?

Dr. **Knapp**. The VLBA will be a 4 year construction project, starting in fiscal year 1985. It will take 4 years of construction time. It will be radio telescopes located from the east coast, Puerto Rico to Hawaii, and also spread through the North and South in the United States. It gives, in effect, a telescope with an aperture the size of the distance between Puerto Rico and Hawaii. It is an incredible thing. There will be a central control station, which will be constructed, which will operate all of these telescopes in concert, and I think our plans are well along this year, 1984. We are developing the final construction plans and should be able to start quite quickly in 1985 with the construction contract.

Mr. **Skeen**. Sounds very good. How many scientists do we plan in this particular project being placed in the little city of Socorro?

Dr. **Knapp**. I will have to defer to the——

Mr. **Skeen**. I was curious. We won't worry about that.

Dr. **Knapp**. We will provide that number for the record.

[The information follows:]

Number of Scientists at Socorro

In full operation, the VLBA will employ about 20 scientists and engineers in Socorro. In addition, there will be about 40 technicians and support staff employed in Socorro and another 10 technicians at the site of the Very Large Array nearby.

Mr. **Skeen**. We were curious just because we are very pleased. What in terms of astrophysical capability—you mentioned the quantum leap in the improvement factor of say 100 to 1,000 of conventional radio and optical telescopes, does this include any improvement over the capability of the space telescope that was planned for launch aboard the space shuttle in 1985?

Dr. **Knapp**. The space telescope is an optical telescope, it spans the visible light range and into the infrared and ultraviolet on either side and images certain kinds of radiation that comes from stars, the optical radiation. The VLBA is a radio telescope. It looks at a different thing. The resolution of the space telescope is very, very good because of the lack of atmosphere for the optical range, but the absolute best resolution that can be obtained in astronomical observations is in the radio frequency region and will be from the VLBA.

Mr. **Skeen**. Dr. Keyworth mentioned some new industrial initiatives in agricultural biotechnology, administered through the Department of Agriculture. I wondered how are these activities and initiatives coordinated with USDA and I understand NOAA has a project and NBS and so forth.

Dr. **Knapp**. We coordinate at the working level, at the program manager level, in those programs. Also, the Controller of the NSF and the Controller of part of the Department of Agriculture and NOAA, who will fund these programs, have been talking together about the funds, and the way they are allocated. We have, of course, programs in the plant sciences at the very fundamental level. The programs in the other agencies are more mission oriented, as those agencies are more mission oriented. We think we have a good understanding of what they are proposing, too, and we think there will be no duplication.

Mr. SKEEN. It is a pretty closely knit, coordinated group. Is that the program level or project level?

Dr. KNAPP. I think it is quite closely coordinated.

Dr. BRANSCOMB. A member of the Board who is an expert in this field has been invited to testify before the Agriculture Committee in this area.

Mr. SKEEN. Who is that?

Dr. BRANSCOMB. Charles Hess.

Mr. SKEEN. Very good. Thank you very much. I appreciate your responses and thank you, Mr. Chairman.

Mr. WALGREN. Thank you.

Mr. Lundine.

Mr. LUNDINE. Thank you, Mr. Chairman.

Dr. Branscomb, I want to direct this to you, although if Dr. Knapp wants to comment, that is fine.

I was delighted but somewhat interested in several aspects of your testimony that suggested to me that NSF is going more in the direction of applied science than sticking rigidly, as I perceive it to have done in the past, to basic research. Is that an accurate impression generally and is that a conscious decision by the Board?

Dr. BRANSCOMB. I am delighted you asked the question, because I think there are many misapprehensions on that score. No, I do not believe that is what we are about, but let me try to answer that a little more completely. It is a very important question.

The Board's policy in engineering is the result of work that goes back through a period, perhaps 4 years ago, when the Board studied intensely the issue of basic versus applied research, and it was really the sorting out of that set of choices that was a prerequisite to generating a policy for engineering that could be workable and correct.

The conclusion we came to was that our view of fundamental research, our view of the mission of the Foundation, is that it engages in the sponsorship of research activities and educational activities that are aimed at the future, that are investigator initiated, that are selected by peer review process, that are openly published and communicated. With those criteria, you can be assured this is not proprietary work of the sort you would expect in industry. But it does not follow that fundamental work of that kind has no utility in the short term. Some disciplines have a higher probability of having high utility in the short term than others. And when we put emphasis on material science, it is not that we are trying to do industry's job in material science, but it is also not simply that material science offers a wonderful adventure for physicists and chemists, because material science happens to be desperately important in modern industry.

That does not dissuade us from investing in it, but it does not cause us to do the kind of materials development that you would expect a company to do.

So, once we had understood that, we made a distinction between very useful high priority fundamental science, which we will do, and problem solving of a commercial nature, which we will not do, both of which are sometimes called applied science. We then gave the responsibility for doing applied science, doing useful science, to the directorates. That was several years ago and that has been, I think, effectively pursued.

We then were able to redefine the Engineering Division which was then called Engineering and Applied Science, and made it an Engineering Directorate in its own right. What we are now about is to give that Engineering Directorate the scope of activity which includes all of the intellectually-challenging, educationally-significant, research-requiring activities that will produce capability. That capability is delivered to industry largely through the people who leave the universities and go to industry to work, but it is also conveyed through literature and the other embodiments of knowledge as it is gained.

I think you will find that if you look in detail at what we are proposing in engineering, it is not to turn the Foundation into a more applied direction, in the sense that it means moving closer toward the work that the companies do. It is very much to broaden the scope of the Foundation a bit significantly in engineering, a bit in the total context, to insure that it does cover all the intellectually exciting areas that are very important to the people of this country.

Mr. LUNDINE. Well, that leads me to a question that I want to try to put fairly. There have been a number of proposals advanced that I would say are all addressed to the possible middle ground in between the two scopes that you just identified, what the companies should and can do in terms of development and research and development, and basically research. They range from a proposal by Lew Thurow, the economist at MIT to provide 50-50 grants with industry to innovate, to George Brown's proposal advanced over a couple of Congresses, I think he calls it technology foundation. Of more direct interest to me right now is the Economic Stabilization Subcommittee of the House Banking Committee has a proposal to create what kind of advanced technology foundation, I think but the name is less important. They call it, they nicknamed it a civilian DARPA, the defense research. The question is, in your judgment, is there a need—all these things are subject to the Federal budget deficit and a lot of realities, that I don't know whether we are going to do it this year or not, but I am interested not so much in that aspect, is there a need that should not or cannot be filled by NSF in the innovation process that appropriately would have a partial Federal role, that somewhat is in between this area of basic research and the privately sponsored R&D.

Dr. BRANSCOMB. There is, obviously, a major appropriate role for the Federal Government in getting quite a bit further into problem solving and in technology in the mission-oriented agencies. The Defense Department and NASA have, for years, engaged in that kind of activity because they had to achieve their own missions. And I believe that is a very appropriate thing to do. But what we should not do is delude ourselves into believing that is a substitute for the fundamental educational scientific engineering capabilities in the country broadly, upon which the civil side of the economy draws. I happen to be a skeptic in the area of spinoff, if one means the genefits to unrelated civilian industrial applications of the major governmental investments in its own programs.

However, there are, of course, important counterparts in the civilian economy, like the air frame industry and the Government requirements, like military aircraft. Therefore, it would be a mistake to say the Government doesn't, in fact, make a major consideration of that character; it does. However, the distinction, I believe that should be made is that the Government should never, should not attempt to spend the public's moneys on the development of technology when the requirement for making good judgments about how to do that call for a modern and sophisticated knowledge of the market and economic realities surrounding the technology. That is what the Government agencies simply do not possess and what companies do.

Mr. LUNDINE. Right. Let me do it and anecdotally, and I appreciate your answer and I know you are answering my question, but I still need a deeper level of understanding.

Recently I had the opportunity to tour Battelle Laboratories in Columbus and found a lot of things they were doing very exciting as a nonscientist, and never lose my amateur status as an engineer for those things, they could translate really advanced work into practical terms that I could understand. You were, for example, recently using the example of material science and they have some basic research they are doing but they also in a machine shop-like or foundry-like atmosphere, under a contract to a couple of steel companies are really getting involved in applied materials engineering of a very practical nature.

Now, I guess my question is, Battelle happened to be created through a grant and that kind of thing. Do we need more of those kinds of things where the interface sort of between proposal-sponsored Government research and company development could come together better?

Dr. BRANSCOMB. I think the answer to that is affirmative. You have given an interesting example. I do believe the Government has a role in institution development and encouragement, and in fact I think that the almost explosive growth of university cooperation through institutions of a whole variety of kinds has been most interesting, been much encouraged by NSF. Some of those will stop at the level of fundamental research and the industry that also wants fundamental research will participate at that level.

Others may well evolve into things like Battelle. But in the example you gave it was the steel companies that were funding that applied work.

Mr. LUNDINE. Right.

Dr. BRANSCOMB. The reason that applied work is going to be useful is because the steel companies are funding it. That is likely to lead to their using the results. They are unlikely to use the results if they are not participating in it and understanding in detail how its utility can be to their advantage.

Dr. KNAPP. I can comment on a couple of things that you touched on here. One about basic and applied research and the innovation process. It is my belief that the connection between university research and industry and the innovation process is primarily through the training of students within the university doing research, more than research which is developed in laboratories and transferred to industry. And the connection to training of the basic research that we do is by far more important to the health of American industry than are particular processes that are developed in university laboratories.

Mr. LUNDINE. Wouldn't you agree that with the fast pace of change in science and engineering today, that you educate a young person and that is the end of that person—following up on Dr. Branscomb's comments, in New York, like several other States, part of the explosion of this idea of university/industry cooperation, which I find exciting, is a series of projects at various universities within the State, where corporate engineers come back and work in the research laboratories more or less just to be updated as to what is going on there.

Don't you think that we have a responsibility not only for engineering schools or scientific schools in the traditional sense up through the Ph.D level but also for this sort of ongoing education process?

Dr. KNAPP. Yes, I think we have a responsibility. You are specifically talking about industrial scientists and engineers returning to the university for certain kinds of work to bring themselves back up to some sort of state of parity with the state of the art. I think that we have a certain responsibility for that, but I think the question, as I understand it, was more are we going more toward applied science and away from the basic sciences, and is that good? And I would say that—we shouldn't ask the question of basic science versus applied science—good things for industry come out of both. If it is exciting science or exciting engineering, it is investigator-initiated; the people who are doing it feel this is pushing the state of the art absolutely to the utmost in whatever field they are in. That is the thing which makes it exciting, gets new results out of it, and gets the best trained people for industry.

Mr. LUNDINE. I realize that my question was not very sharply drawn, but both of you have put the whole matter into better focus for me. I would like to ask one further question. I realized I may have exceeded my time limit.

Dr. Knapp, with some apologies, I don't think I am going to be able to be present at the further hearing where you are going to appear, and I am just very generally interested in your supercomputer project. I understand that you have an advisory group that is meeting on this and I wonder if you could give me a quick thumbnail sketch of what you are going to tell the subcommittee in more detail next week.

Dr. KNAPP. Thumbnail?

Mr. LUNDINE. A sneak preview.

Dr. KNAPP. It is a fairly complicated question and our approach to the supercomputer initiative is designed on our historical way of doing things within the Foundation; namely, as we were just speaking, with investigator-initiated proposals, which we look at, with a lot of committee involvement. As Dr. Branscomb said, last summer, we had the results of the Lax panel, which was an NSF/DOD panel, which indicated that there were two very serious areas of neglect in the support of supercomputers, both the access for university users and university research and other research in the architectures and hardware associated with computers.

We did an internal study. We felt that within the Foundation the place that we with our limited funds could have the most impact immediately was providing access to computing power for academic researchers in all fields of science. We did a study, other people have done studies, we tried to assess the need. The need is extremely difficult to really come to grips with. It is partly the problem that the university scientific community has not had access to these computing facilities so they don't know what they don't have.

And how do we develop a feeling of what the need is for this access and how do we go about giving this access? Well, it immediately became clear from other precedents in other agencies that a few centers with large-scale computing facilities and a network which covered the country to the interested or using scientific population was the best way to go to provide access to very high-powered computing for academic researchers and that while we didn't know exactly the final size of the system that would really satisfy the needs of the country, we should get started. So we have started this year. The directorates themselves have set aside some funds to get started in buying from existing university-based computer facilities time for the use of academic people in all disciplines through a very rudimentary network which already exists in some cases and will be augmented with the funds starting this year.

Next year we are proposing to expand that. The committee that we have, this advisory committee, has met for its organizational meeting. It is developing rather explicit positions on how the community feels we should go with the network and with the center or centers, depending on how this all works out. We are involving the community of users very deeply in the process of our response, and I believe that we are going to have within the next few months a rather detailed set of proposals for the way we develop the network, the way we develop the terminals, the nodes, how this information comes in and leaves the university, and the structure or the organization of the center, which would include the supercomputer.

I don't know if that answers your question. It is supposed to be a thumbnail sketch, but——

Mr. LUNDINE. It helps me, it advances my knowledge by a quantum.

Thank you.

Dr. KNAPP. I might comment on this one thing. We are associated with peer reviewed, investigator-initiated proposals, so the proposals for the centers will be a competitive set of proposals which come from universities to provide computing power, and we will judge amongst them and allocate the funds we have for this on the basis of their proposals, not our plan. I think their proposal has to fit our overall structure, but we are not going to tell a university how to internally structure its own response to that particular question or that particular request for a proposal.

I think that is a very strong power of the NSF and the way it does its business. We get new ideas, good ideas. Everything is not organizationally uniform in the universe of people who make proposals to NSF, and I think we get really very innovative solutions to problems by approaching the problem that way.

Mr. **Walgren**. If the gentleman would yield.

It would be a good time, I think, to pursue the same subject.

As I understand it, there were at least concrete proposals for a larger initiative in supercomputers than just focusing on the network. And there was one report within the NSF structure that asked for $200 million in terms of what an adequate funding level would be, and that was to run at that level for 3 years providing 10 computer centers.

Can you tell us a little bit about the dynamics between NSF and OMB and what did you go into OMB for in this particular need and then what came back out.

Dr. **Knapp**. We went in with a considerably larger request than we have before you. I don't remember the exact number. We had an extensive debate on the extent of our knowledge of the need for supercomputing facilities. As I explained, the need is very difficult to get your hands around. There are studies which have been done which could indicate that one supercomputer is adequate for all of the aspects of a program very near the size of ours in the Federal Government.

There are other studies. The internal NSF study indicated ten supercomputers would be a good number to have in the field for academic access. There are other studies which have indicated even more.

We feel that, in fact, in the steady state after we have satisfied this need, we may need considerably more money than in the budget for 1985. However, we feel that a prudent approach to this problem would have us starting with the $20-million program that we have in the budget, establishing a supercomputer center or two in a university, or several universities, getting our network established, and getting our feel for the proposal pressure and the need within the scientific community for this computing, based upon the kind of proposal pressure that comes into us, rather than on surveys which are very difficult to bench mark as to their reliability.

So we think that the $20 million that we are putting in the budget for 1985 is a good start toward a system which undoubtedly will be considerably larger in the final steady state situation.

Mr. **Walgren**. $20 million, of course, sounds like a lot of money. How does the third machine at the National Center for Atmospheric Research fit into that? Is that going to take any off that money?

Dr. **Knapp**. No; that machine is purchased over and above the supercomputer initiative. It is not counted in the $20 million.

Mr. **Walgren**. I see.

As I understand it, there was a suggestion by the committee that we get some kind of a formal report on your proposal for networking, that would be thought to be coming about this time from the Science Foundation under last year's authorization effort the committee went through. Is there a formal report on scientific computing and networking that the Foundation is working on for the Congress?

Dr. **Knapp**. I think we have submitted that report to you. I think I signed a letter on January 17 which transmitted the so-called Bardon-Curtis report which we think does satisfy the requirements of your request.

Mr. **Walgren**. It is the view of some that that particular report, that Bardon report, does not describe an adequate plan for network development or use of existing networks and, along this line, I understand that we are going to contract out the present computer center network, is that what you call it?

Dr. **Knapp**. Yes.

Mr. **Walgren**. Although you feel that that might satisfy the requirement, do you think that this Bardon report is sufficient guidance to lay out where we immediately need to go with respect to networking?

Dr. **Knapp**. The computer science net, or CSNET, as it is called, is not adequate in its present form to satisfy the needs of the scientific net that would connect these supercomputers. However, it is an existing network which can be used for communicating between universities and computers. The advisory committee, which met earlier this week and which is going to return with some recommendations after considerable study on March 5, is going to come to us with specific recommendations for a specific architecture for a network and there are possibilities that parts of the existing networks can be part of that overall network. It also might be a completely new network. There are many, many possibilities and alternatives. We should have a very firm set of recommendations from inside the Foundation and that committee by March 5 for the network.

Mr. **Walgren**. You mentioned you went to OMB asking for considerably more. What exactly did you request from OMB?

Dr. **Knapp**. $47 million.

Mr. **Walgren**. And that would have done more than network alone?

Dr. **Knapp**. Within the $20 million, we will roughly spend half of that money for a supercomputer center and half for the network. However, it is developed and it is the budgeting for that and the detailed plan on how to do it that we will be discussing on March 5. We do have more than networking in the plan for 1985. Now, in 1984 we will not be purchasing computers. We will be buying computer time from one or more of the existing university-based computer centers. They are Colorado State University, University of Minnesota, and Purdue University. It will only be networking in 1984 and planning, and it will be buying time. It will be, most probably, the establishment of a major computer center at a university campus in 1985 as well as networking.

Mr. **Walgren**. If the previous report recommended 10 centers and you are establishing 1, would it be fair to say that if we were, if the Congress were to provide more money for that particular initiative, that it would go toward more centers?

Dr. **Knapp**. I think it would go toward more centers and more extensive networking. We have tried to keep the balance proper between the various aspects of the program.

Mr. **Walgren**. Has the science board been involved in this, in the program on supercomputers, Dr. Branscomb?

Dr. **Branscomb**. Yes, we have, Mr. Chairman. I described that briefly in my opening testimony. We have reviewed—as I said, the Lax report was done by one of our members. We had a lot of discussion of it at the time and we reviewed the Bardon report and the Director's implementation plans. Of course, this program has been evolving in some detail. The Board is not immediately up to date on things like advisory committee work this week, but we will be at our next meeting.

I think perhaps I should make one or two general comments. The so-called supercomputer issue in part derives because there is increasing evidence and conversation on the part of some very brilliant and successful scientists that very large-scale computing capability can make a qualitative change in how science can use computers to advance. I am sure you are familiar with the fact that a mathematician successfully used a computer to prove certain theorems in mathematics that have never yielded before. There are scientists, like Dr. Wilson, who also believe that one can begin to discover knowledge with the aid of a computer, not simply more efficiently do the science the old way.

However, I think there is more to the issue than access to a few isolated very large machines. The trend over the last 15 years, in university computing has been toward a very heavy decentralization of the university computer center activity, down to the departmental level, and computer power has been put into the hands of individuals and small groups. This has given a lot of flexibility, a lot of spontaneity, to the use of computers scientifically.

At the same time, the access of individual scientists to substantial amounts of continuous computer capacity, which you cannot get from a small departmental machine, has been attenuated and we are looking not only at the need for a few unique very large machines; we are looking at a very broad requirement for the upgrading of computer intensive research capability. I suspect that the Foundation will learn a lot in the next 2 or 3 years as the universities really take this subject seriously, now that they are discovering why they should, and the Government is taking it seriously, and we will see an evolving range of requirements.

The other comment I would make is that the NSF studies have, very wisely, said that, for a very large computer facility to be efficiently used by scientists for research, it needs to be staffed in depth. The users of these machines are physicists, chemists, mathematicians. They are, by and large, not computer scientists. These people in these other disciplines are knowledgeable about computers. It takes more than just knowledge of computers to use efficiently a very large machine, so the centers the Foundation creates need to be staffed in depth with expert system programers, systems engineers, mathematicians, and applications expertise. That is going to take time and be difficult to manage. I am very much in favor and the Board is in favor of it, getting a start down this path, putting enough flexibility into the program so we can learn as we go, because I think we will learn a lot and the program 5 years from now will be exciting and look rather different from what we would guess it to be today.

Mr. **Walgren**. Mr. Skeen.

Dr. **Knapp**. I have one more comment. I have a draft in front of me of the first report of the Advisory Committee for Advanced Scientific Computing Resources, and we would be happy to submit this for the record, if you would like, in a few days when it is no longer draft but is the final report.

Mr. **Walgren**. We would appreciate having that. That is not the committee that you said had its organizational meeting last week?

Dr. **Knapp**. Yes, it made some recommendations.

Mr. **Walgren**. It is moving right along.

Dr. **Knapp**. It has made very nice recommendations and talks about the cooperation and exchange of resources among all members of the scientific, engineering and computational community. It doesn't talk about details of networking or details of centers, but it talks about the philosophy and the goals of the program that we are putting forward. I think you would find it interesting.

Mr. **Walgren**. We would appreciate receiving that.

[The information follows:]

NATIONAL SCIENCE FOUNDATION
Washington, D. C. 20550

ADVISORY COMMITTEE FOR ADVANCED SCIENTIFIC COMPUTING RESOURCES

Prologue

The first meeting of the NSF Advisory Committee for Advanced Scientific Computing Resources was held on January 30-31, 1984. The following summary statements contain the spirit of the Committee's views and their recommendations.

A succession of committee reports document the need for a national initiative in advanced scientific computing for the U.S. university research community.

The Program Advisory Committee is charged with advising on the implementation of an initiative. Our recommendations have been formulated from the perspective of a long-term overview of the objectives of the initiative. We shall therefore state those objectives and background as we see them and our overall recommendations to NSF for implementation.

Science and Advanced Scientific Computing

Science is undergoing a structural transition from two broad methodologies to three, namely from experimental and theoretical science, to include the additional category of computational and information science. A comparable example of such a change occurred with the development of systematic experimental science at the time of Galileo.

The current transition affects every discipline of science and engineering and every university engaged in scientific research. We expect that the new opportunities for scientific inquiry and industrial applications of science made possible by large-scale computational support will feed back into total global scientific activity, in theory, experiment and computation. Industry is becoming increasingly dependent on large-scale computation to help design products that are competitive in world markets; its needs for breakthroughs in research and for trained manpower should help swell total scientific activity.

New scientific opportunities develop every time there is a major advance in computer system capability, for example, advances by a factor of ten or more in speed, memory size, and peripheral storage. The scientific opportunities made possible by present technology are still far less than what may come in the future due to the very great complexity of nature itself. For example, a typical liquid sample contains 10^{23} atoms (1 followed by 23 zeros); the simulation of such a liquid today on the largest computers is limited to a few thousand atoms, or a sample 10 atoms on a side. This is insufficient for accurate descriptions of liquids due to large statistical uncertainties arising from the use of too few atoms. The NSF should promote research in hardware and software and numerical analysis that can lead to major increases in the future in computer power and usability.

An Integrated Science and Engineering Community

The U.S. has a broad community of scientists and engineers engaged in computational activity that is scattered throughout private industry, universities and national laboratories. The computer industry has a major marketing and product development effort supporting large-scale scientific computing. Supercomputers are only a small part of the total computing industry effort. The research community is presently fragmented into independent disciplinary groups like the Society for Exploration Geophysics or the Computational Chemistry Division of the American Chemical Society; users groups for different computing systems such as IBM's Share or the Cray users group; into distinct academic disciplines such as Physics, Mechanical Engineering, or Computer Science; into university groups, industry groups or national laboratory groups. However, everyone engaged in computation faces a common set of problems, such as the issues of low software productivity, inadequate sources of trained manpower (for research, engineering or computer support), and inaccessibility to advanced technology for computation.

A MAJOR GOAL OF THE NSF ADVANCED SCIENTIFIC COMPUTING INITIATIVE SHOULD BE TO PROMOTE COOPERATION AND EXCHANGE OF RESOURCES AMONG ALL MEMBERS OF THE SCIENTIFIC AND ENGINEERING COMPUTATIONAL COMMUNITY. IT SHOULD ALSO HAVE THE OBJECTIVE OF ESTABLISHING UNIVERSITY RESEARCH AND ADVANCED TRAINING AS A FULL-FLEDGED PART OF COMMUNITY ACTIVITY.

There are several significant specific consequences of this recommendation. The computing technology available for university research and advanced training should be fully equal to that available to the rest of the community. In fact, it is desirable that new technology go first to the universities so that graduate students can be trained in its use; trained manpower thereby becomes available simultaneously with commercial introduction of this technology. FOR THIS REASON, WE BELIEVE THAT ACCESS TO THE LATEST, MOST POWERFUL COMPUTING TECHNOLOGY, FROM WORKSTATIONS TO SPECIALIZED PROCESSORS TO SUPERCOMPUTERS, IS ESSENTIAL ON UNIVERSITY CAMPUSES.

Closer cooperation among members of the scientific and engineering computational community requires concrete steps by the NSF. The most effective means known currently for achieving wide interdisciplinary communication is use of computer networks, illustrated by the Arpanet. THE NSF SHOULD GIVE IMMEDIATE PRIORITY TO A NATIONAL NETWORK FOR ALL DISCIPLINES OF SCIENCE AND ENGINEERING, STARTING WITH THE UNIVERSITY COMMUNITY SUPPORTED BY THE NSF BUT SEEKING AS RAPIDLY AS POSSIBLE TO EXTEND THE COVERAGE OF COMPUTER COMMUNICATION NETWORKS TO THE FULL SCIENTIFIC AND ENGINEERING COMMUNITY IN INDUSTRY AND GOVERNMENT LABORATORIES AS WELL.

Another form of cooperation is the development of university-computer-vendor ties. Past experience has shown that computer design and marketing are sufficiently difficult tasks that close cooperation between a university and a vendor can have qualitative impact on the vendor's commercial success. A top university can supply researchers with expertise in a wide range of areas from circuit design to specific scientific applications; it can start training students on prototype systems supplied by the vendor in advance of full commercial productions; the rapid diffusion in universities of both basic scientific knowledge and practical experience with computers of many types can supply vendors with an intelligent but critical view of the particular product's strength and weaknesses. In return the vendor is likely to supply major help to the university in question - deep discounts or donations for equipment, exchange of personnel, informal arrangements for use of equipment on the vendor's premises, etc. This is a form of cooperation that NSF should encourage. NSF SHOULD CONTINUE TO COOPERATE WITH UNIVERSITIES TO DEVELOP GUIDELINES TO PROTECT BOTH THE ACADEMIC FREEDOM OF THE UNIVERSITY PARTICIPANTS AND THE PROPRIETARY RIGHTS OF THE INDUSTRIAL PARTNERS IN SUCH VENTURES.

A third form of cooperation involves interdisciplinary groups at individual universities, bringing together scientists and engineers and others to collaborate on common computational problems and to build a common equipment base for their research. WE URGE THAT THE MODEL OF INTERDISCIPLINARY GROUPS WITHIN SINGLE UNIVERSITIES OR UNIVERSITY CONSORTIA BE GIVEN EQUAL IF NOT HIGHER PRIORITY THAN SINGLE DISCIPLINE APPROACHES TO THE SOLUTION OF COMPUTATIONAL NEEDS. It is especially important that there be exchange between research in numerical analysis and computer science and research in traditional scientific disciplines.

One very important reason for the NSF to emphasize cooperation is that it would make possible the support of university research and training needs from a wide variety of sources - state governments, computer vendors, industrial users of computing, etc. A bold NSF computational initiative with sufficient funds should set in motion a scientific and industrial syngerism with far greater impact than NSF funding could achieve by itself. WE URGE NSF TO DO EVERYTHING POSSIBLE TO SEE THAT FUNDING FOR THE INITIATIVE REACHES THE THRESHOLD LEVEL TO ACHIEVE FULL COOPERATION FROM THE REST OF THE COMMUNITY IN ELEVATING THE TOTAL PROGRAM TO FULL EQUALITY WITH EXPERIMENTAL AND THEORETICAL SCIENCE.

Requirements for Progress

Several barriers to progress in computational and information science need to be addressed by the advanced scientific computing initiative. Some of these are common to industries-universities-national laboratories; leadership by NSF-supported universities in solving these problems should also bring major outside support to universities.

The issues to be dealt with include the following:

o The fundamental problem of software productivity is driven by limits to the complexity of a computer program that a single human can comprehend. Many scientific and industrial problems substantially exceed this complexity limit. Collaborative efforts between natural scientists and computer scientists are needed to address this problem.

- Full equality between remote and local access to high-performance computing systems must be achieved. THIS MEANS THAT NSF MUST CONFRONT HIGH BANDWIDTH NETWORKING ISSUES SO THAT FULL THREE-DIMENSIONAL COLOR GRAPHICS AND OTHER HIGH-SPEED DATA TRANSFER REQUIREMENTS CAN BE MET FOR USERS OF A SPECIFIC FACILITY FROM ACROSS THE U.S. Given the broad range of special and general purpose systems that is needed for a full program of computational and information science, there is no possibility that every user would have local access to the most effective computer for her/his needs except if networked appropriately.

- For universities to carry out their training mission successfully, they need local prototypes of supercomputers, which students can use for training without large expenditures of funds or blocking network bandwidth. To establish this training program requires high capacity computers with a reasonable cost. For example, the availability of inexpensive software-compatible versions of future supercomputers could be very valuable to the NSF initiative.

- Universities need an infrastructure of local area networks with superminicomputers, desk top work-stations, and full software and expert personnel support if faculty and students are to achieve full scientific productivity either locally or through remote access to major centers. THE NSF SHOULD HAVE A SPECIAL INTERDISCIPLINARY PROGRAM WORKING WITH UNIVERSITIES TO ESTABLISH THIS INFRASTRUCTURE AND MAKE IT AVAILABLE FOR A FULL RANGE OF RESEARCH AND ADVANCED TRAINING NEEDS, EVEN IN RESEARCH AREAS WHERE COMPUTING DEMANDS ARE NOT YET WELL DEVELOPED.

- There is a need for continuing research in hardware and software and numerical analysis that can lead to future major increases in computer power and usability. THE NSF SHOULD SUPPORT RESEARCH AND ADVANCED TRAINING IN THESE AREAS. THE NSF SHOULD ALSO SUPPORT EFFORTS TO ACHIEVE VERY HIGH COMPUTING POWER ON SPECIALIZED ARCHITECTURES FOR SPECIAL APPLICATIONS.

Budget Considerations

Computational and information science has the same basic dependence on equipment as does experimental science. WE BELIEVE THAT COMPUTATIONAL AND INFORMATION SCIENCE SHOULD EVENTUALLY HAVE ABOUT EQUAL PRIORITY AND FUNDING LEVELS WITH EXPERIMENTAL OR THEORETICAL SCIENCE. Even for the immediate future, the Bardon/Curtis report identified a need for a $180 million budget for the supercomputer initiative. WE AGREE THAT IMMEDIATE NEEDS ARE OF THIS ORDER, AND EXPECT THAT FUTURE REQUIREMENTS WILL BE HIGHER.

At present, the NSF Advanced Scientific Computing Initiative has $6M available in Fiscal Year 1984. We have already encountered difficulties in deciding the allotment of these funds because they fall so short of the need. We face demands from every program of the NSF in science and engineering. We face demands for many different kinds of computing, not just supercomputing. We face the task of building an infrastructure of local computing facilities at every NSF-supported university in the U.S. so that researchers and graduate students can have full access to computing facilities in support of research and training. Until adequate funding becomes available, it is difficult to enable progress in the full range of research and graduate training programs that require computing support.

Neal F. Lane, Chairman
Advisory Committee for Advanced
Scientific Computing Resources

Mr. **Walgren**. Mr. Skeen.

Mr. **Skeen**. Thank you. I appreciate the courtesy. And Dr. Knapp and Dr. Branscomb, I noticed that in these grants, and I am delighted that we are putting more money into research and grants and so on, how closely do you examine the overhead costs to universities and so forth so they are extracted from these funds, because they range anywhere from 35 up to 70 percent and I am sure there is some justification depending on what kind of work is going on. I was curious.

Dr. **Knapp**. I have personally looked at that briefly. It seems that every university in the United States has a different accounting system, a different set of rules on what is to be included in its overhead charges and what is not, what is to be charged directly to the grant and what is to be charged into the overhead. That is the reason for the wide disparity between 30 percent and 70 percent. It is the definition of what is overhead rather than——

Mr. **Skeen**. I see.

Dr. **Knapp**. Some places are more expensive to do work than others. Each university is audited by an agency of the Federal Government, not the NSF, and its rules are established and overhead rate is established for it. The disparity is not anywhere near as much as 30 to 70 percent. However, the overhead rates have been climbing for universities, generally, under the same rules. In discussions with OSTP, Dr. Keyworth and his staff, they believe that we really must over the next year look into the whole problem of overhead costs in some detail, and are we in fact supporting universities for research in an adequate way. Is it too much, too little? We need to understand better than we do right now the overhead cost problems that universities have. Is that why university buildings in which a research is housed are basically disintegrating in some cases because they have no—they are not receiving enough overhead support for maintenance and repair. These sorts of questions are very important to the university community in the United States and we are hoping to look into that.

We have been requested by the OSTP to have that issue as a topic for the Board's consideration at its summer meeting. We have not decided whether we will do that or not, we have several other things that are quite interesting to discuss, too. But that could be one of the topics that we will look at quite closely at the June Board meeting.

Mr. **Skeen**. Which agency does your audits for you? Is it an agency?

Dr. **Hayes**. The Department of Health and Human Services (HHS) does the——

Mr. **Skeen**. It is HHS that does?

Dr. **Hayes**. It depends on the institution.

Mr. **Skeen**. You have no one base audit group that summarizes this activity or you just depend on whatever agency that you are dealing with or whatever institution you are dealing with to do the audits? Is that what you are telling me?

Dr. **Hayes**. There are Government-wide principles.

Dr. **Knapp**. This is Dr. Hayes, the Controller of the Foundation.

Dr. **Hayes**. Yes, the Government-wide principle established for what are appropriate charges to the indirect costs and each university is audited by a specific agency, so that you don't have two or three different audit groups coming in and most of the institutions where we have grants are audited by the the NIH people.

Mr. **Skeen**. DOD?

Dr. **Hayes**. There are also some of the institutions that are audited by ONR, and there are a few institutions I understand that in fact are audited by NSF staff.

Mr. **Skeen**. I thank you very much.

Dr. Knapp, I would like very much if we could be kept aware of what your discussions are on the line because there is a wide disparity. I think as an understanding that every case is probably different and whatever accounting or auditing principles and so forth we would kind of like to see how they are handled, too. And I am sure that our universities do a good job of handling it. When it runs up to 70 percent of the money that is going to a particular effort, research, and some 70 percent is taken out as overhead cost, it tends to give you some concern.

Dr. **Knapp**. I think it is 70 percent in addition to the 100 percent, which is the straight cost. That is the way that is calculated.

Yes, it is still large—almost half of the funds can go to the overhead in some cases and that seems quite high. We will be looking at that and will be pleased to keep you informed.

Mr. **Skeen**. I appreciate that very much.

Thank you, Mr. Chairman.

Mr. **Walgren**. Dr. Knapp, as I understand it, the budget that is proposed will eliminate the Experimental Program to Stimulate Competitive Research, which was an effort by the Congress to sort of distribute this involvement of NSF across the country, really to maintain a broader constituency for the program, I am sure more than anything else. It is true that it may be that if we were to follow only the peer review and most interesting proposals that all the research would wind up in one little part of the country, that the rest of the country would not have a stake in supporting.

Is there any ability of NSF to replace that program or provide for this kind of involvement of institutions across the country that we have tried to maintain in the past through that program?

Dr. **Knapp**. That program is not terminated, it is continuing. There are five programs, the programs that were funded in 1983, for a number of years, and we expect that program to terminate at the end of 1985 with funds which were assigned to the program from earlier years. There are no funds in the 1985 budget, but the program is continuing in 1985 and will come to its conclusion at the end of 1985. It is an experimental program, and before we follow on with an additional program we feel we should look at the results of that program.

Has it stimulated competitive research? Have the States where the institutions carried out these programs become more competitive and are they now achieving success in the ordinary standard programs of the National Science Foundation?

We will be looking very carefully at the results of this program and we will try to understand if this is a valuable program to continue in the future.

Dr. **Branscomb**. Could I make a comment about the influence of dependence on the peer review system on this issue of opportunity in various parts of the country?

I can understand the concern you expressed that the strong may put in the best proposals and, therefore, always have an advantage, but in fact, the peer review process and it traditionally goes with it, also protects the diversity. It is possible for a young person—very well trained in one of the major centers—to take a teacher job in a modest institution in someplace without a great research tradition and because that person carries a lot of excellent ideas and fine personal reputation they can get a grant and get started where they are.

I think if we were to trace some of those examples we would find that the peer review process has really been an avenue through which talent disperses and new centers are grown.

Mr. **Walgren**. As the interesting research becomes more and more based on previous access to a complex technology base, that becomes less and less likely?

Dr. **Branscomb**. It poses a very special dilemma and the dilemma is that if that new grantee that goes into the emerging area is not able to get adequate level of support, and adequate equipment, then, of course, they may not be able to compete against those who are in a place that is very well equipped. Therefore, the need to be able to give such a grant an adequate level of equipment is an important element in competition and yet it is precisely the necessity of adequately funding the individual research project that puts pressure on the number of projects that can be supported.

We can't have our cake and eat it too. If we are going to let this dispersion take place, we have to be able to put enough funds in a single grant so they can compete.

Dr. **Knapp**. I might comment within the Foundation this year we are starting a program within the research directorates to change the rules slightly under which the peer review process is conducted for proposals which come from primarily small colleges which have very small graduate programs. The Research in Predominantly Undergraduate Institutions program is for that class of universities and colleges, no matter how they put in a proposal, whether it be under the special program or in general. We are trying to take into account within the Foundation the aspects of undergraduate training which may be associated with that program and make that part of the peer review process as well as the excellence of the research.

The excellence of the research, of course, is a part of the judgment, but there are certain constrictions on, restrictions on how research can be carried out at relatively smaller places. We are trying to increase the support of predominantly undergraduate institutions by a fair amount in 1984 and that will continue in 1985. It doesn't show as a budget item but I think it is going quite successfully in the Foundation right now.

Mr. **Walgren**. Are we correct in understanding that there was an interim report made to the Director on the effectiveness and the value of the competitive research program and, if so, could we have that for——

Dr. **Knapp**. I don't recall that exactly, but I recall discussions that I have had about that which indicated that in some cases this was quite an effective program and other cases it was not particularly effective, and we were continuing but we didn't want to make a judgment on the entire program until it was finished.

Mr. **Green**. There is data available which we could make available.

Mr. **Walgren**. We would certainly appreciate that.

[The material follows:]

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EPSCOR Report

Summary

This paper provides a status report on The Experimental Program to Stimulate Competitive Research from its beginning in January 1978 to October 1983.

The Program was established in 1978 by the National Science Foundation in response to a recommendation from an NSF Task Force on Geographic Distribution of NSF Awards. Discussion leading to its establishment recognized the local, as well as national, importance of a strong science base, the benefits of a diversified and widespread performer pool, and the major contribution that a merit-based peer review system has made to the strength of the nation's science and engineering enterprise.

EPSCoR was established as a five-year effort to increase the ability of scientists at universities in five states to compete successfully for Federal research funds. The groups of scientists are in Montana, West Virginia, South Carolina, Maine, and Arkansas.

In May 1979, university based groups in seven states were awarded planning grants to assess their science and technology capability and to develop a five-year program of self improvement. In October 1980, the NSF provided awards of $2.5 to $3 million to universities in five states to help support state-wide research improvement plans. Similar amounts were awarded in fiscal years 1982 and 1983 and the final increment of $2.5 million to the participating states will be made in FY 1984.

The awards were based on a thorough peer-review process that analyzed scientific merit and feasibility of each group's plan and the state's commitment to improving their programs in basic research. Each state's support for this endeavor was evidenced by cost-sharing provisions, favorable attitudes of academic and public leaders, and improvement strategies beyond the five-year duration of the grant.

We can already discern the following results:

-- the quality of the faculty in participant institutions has been improved (e.g., nationally-respected earth scientists were hired in Maine; a noted chemist and a respected European physicist were hired by South Carolina)

-- over one-half of the 183 EPSCoR-supported scientists have already received other Federal awards

-- the interaction between scientists in participant states and nationally recognized scientists has increased significantly (e.g., South Carolina used over 125 nationally competitive scientists in their planning process; and over 50 nationally recognized scientists have visited Montana to work with faculty and present seminars during the last year and over 500 different scientists from outside the state have served as peer reviewers of proposals developed by Montana faculty)

-- scientists in the five states now recognize that what they believed were biases by funding agencies and reviewers were not the real reasons for their failure to compete

-- participant scientists are getting increased exposure as a consequence of their work, and research productivity has been increased (e.g., the work of a Montana scientist funded by the program will be featured in October 1983 on the television program 20/20; his work is now supported by the NSF Geology program; a Maine scientist has developed an innovative method to measure nitrates in seawater which is more sensitive than conventional techniques, and now his work is supported by the NSF program areas)

-- basic research has taken on increased importance and the research "spirit" is higher than ever in participant states

-- community and industrial involvement in local efforts to improve research has increased and provided some very beneficial results

-- in all states, internal communication between scientists, administrators, legislators, and the community has been improved (e.g., in Arkansas state-wide research groups have been formed in laser physics and mathematics; in Montana, the two research universities are working closely with each other and with the State Commissioner of Higher Education to build research).

Program Accomplishments to Date

The accomplishments presented below consist of statements of fact, as well as, perceptions of the value of the program. At this early stage, perceptions can not always be substantiated. They are presented as initial indicators of change and support within participating states for a stronger basic research effort. Some of these indicators will be tracked over the five-year program.

1. One hundred-eighty three scientists and engineers received research initiation support, which means more time for research, better equipment and support staff, and increased access to recognized experts in their field.

2. Other faculty, including already competitive scientists, are benefitting indirectly (a) through greater interaction with higher quality faculty, post docs and consultants and (b) as secondary users of equipment and new technical support personnel.

3. Administrators in participant states have a truer picture of the capability of their science and engineering staff relative to national standards of excellence; their perception of the value of peer review to make science and engineering decisions and to develop staff capability has been enhanced.

   For example:

   - Prior to submitting proposals to outside agencies, Montanans on a New Trac for Science (MONTS) acquires "expert" reviews for investigators. Such prereviews have strengthened the link between Montana scientists and outside experts and have increased Montana's appreciation of the value of the peer review. Since its start in 1980, MONTS has obtained reviews from 550 outside experts and 70 other Montana scientists. Included in the outside experts were 35 reviewers from 11 foreign countries. Reviewers included Nobel Laureates D. Baltmore and H. Temm.

   - Montana notes that as a consequence of their use of the peer review system to select MONTS participants, collaborative projects between Montana scientists and outside reviewers were initiated.

4. The general positive attitude toward NSF has been enhanced; the belief that NSF discriminates against "outlying areas" has been reduced.

5. Basic research has taken on increased importance; the research "spirit" is higher than it has been in participant states.

For example:

- The central administration of West Virginia University is providing increased support services to help faculty develop better proposals; this is being funded with local funds.
- MONTS, in a three month period, generated more research proposals than the total submitted to NSF by Montana scientists in the preceeding five-years.
- Montana will commit $900,000 in state funds as cost-sharing to the program in years 4 and 5. After NSF, the program will be continued at around the $400,000 mark. Currently, NSF is supporting 4 investigators in Montana and the state is supporting 23 projects. The project has the strong support of the Commissioner of Higher Education in Montana who serves as the MONTS Chairperson.
- South Carolina will commit $2 million in matching funds to the EPSCoR effort; Additionally, all indirect costs were waived on the $2.7 million NSF award. All cost-sharing funds have been added to the participating departments and will be continued beyond the NSF grant.
- In Arkansas, the EPSCoR program has generated new attitudes about research. Adding up all contributions, Arkansas is contributing nearly $4 million to the EPSCoR effort. New policies have been instituted, providing greater release time for faculty research. This emphasis on research as a central activity at the graduate level is spilling over into the undergraduate colleges where it is building enthusiasm for careers in science and engineering.
- In West Virginia, state funds were used to initiate 5 new projects in the past year. The university provided $171,000 of new money for this activity. In year three alone West Virginia cost-shared in the amount of $392,000. Over the five-year period West Virginia University will provide $1.9 million in cost-sharing to the NSF's $2.7 million.

6. Participant scientists are getting increased exposure as a consequence of their work; their research productivity has been increased.

For example:

- A South Carolina statistician has been invited to Italy and Mexico to present his work;
- Dr. Chris Garside, a Maine scientist, has developed an innovative method to measure nitrates in seawater which is much more sensitive than conventional techniques; his work is now supported by the NSF Ocean Sciences Research Section. The Office of Naval Research (ONR) is also interested.
- The University of Maine, Orono (UMO) Geology Department hosted the Northeastern sectional meeting of the Geological Society of America; 1000 geologists attended; knowledge of the addition of two nationally competitive scientists to UMO's staff has caused an increase in the number of scientists seeking cooperative efforts with UMO;
- Two West Virginia participants are chaired sessions at professional meetings;
- West Virginia has designed supplemental programs to increase the visibility of individual participants; faculty travel is being supported to allow investigators to interact with the senior level leadership in their fields;
- In Montana, 50% of the investigators who have been associated with the Experimental Program have acquired outside funding. Further, the MONTS program stipulates that no state cost-sharing dollars will be provided to any MONTS investigator who does not prepare a proposal for outside funding within 16 months of receiving the state MONTS money. As of June 1983, 68% of investigators on NSF dollars and 79% of state MONTS investigators had submitted proposals for outside funding. Collectively, MONTS grantees published 167 papers in edited scientific journals since October 1980.
- More NSF program directors have been in Montana during the last 3 years than in any other comparable amount of time in the history of the state.
- In South Carolina, Dr. Burke, a targeted faculty member, now has three NIH grants totalling $603,000. Another targeted faculty, Dr. Dawson, was awarded an NIH career development award, a Drefus Foundation award, and a Sloan Foundation grant.

- As a result of his work in EPSCoR, Dr. Cowen of USC was invited to participate in an NSF sponsored U.S. - Australian Seminar on Design and Implementation of Computer Based Geographical Information Systems.

- In the state of Maine 18 targeted faculty were designated. These individuals submitted 58 proposals for outside funding from January 1982 to June 1983; 19 of these were funded for about $985,000 and 12 of them were regular NSF grants.

- In Arkansas, EPSCoR supported scientists have published over 200 journal articles. They have submitted 53 proposals and have obtained almost $1.5 million in extramural support (exclusive of EPSCoR).

- In West Virginia, of the 19 EPSCoR investigators, 10 have submitted proposals for outside support. Three proposals were funded; one was declined; and the remaining six are still pending. EPSCoR investigators published 70 papers in referred journals.

7. The interaction between scientists in participant states and nationally recognized scientists has increased significantly.

For example:

- Virtually all participating scientists have funds in their grants to interact with nationally recognized leaders in their field; many are sperding summers or sabbatical years with these leaders. One Montana scientist after spending six months at Cornell University, returned to Montana, wrote a proposal to NIH, and was funded for nearly 250k.

- South Carolina used over 125 nationally competitive scientists in their planning process.

- As a result of contacts made with Dr. R. Marshak (Program Site Visitor), a South Carolina physicist was invited, with a number of Nobel Laureates, to a conference at VPI to discuss his work.

- West Virginia brought consultants into the state to evaluate the progress of participant scientists after nine months; individual progress reports are being peer reviewed by mail reviewers.

- West Virginia is providing participant scientists with mini-sabbaticals which will allow them to work up to one month per year outside the university.

- A Montana physicist is now working closely with one of the top U.S. groups in parity violation in atoms at the University of Michigan.

- o Close to 40 nationally recognized scientists visited Montana during the planning process; another 150 have visited MONTS participants in the first three years. Scientists are encouraged to invite to Montana at least one or more influential scientist(s). Consequently, many nationally recognized scientists have participated in the MONTS program.

- o As a consequence of EPSCoR, Dr. Endre Szemeredi was brought to USC as a visiting faculty member. In conjunction with T. Trotter at USC, they have solved two well known problems in Ramsey theory and combinatorial geometry. USC has gotten national attention. The USC math department was one of a select few to receive an NSF Scientific Research Computing award.

- o In the Spring 1983, Montana State Chemistry Department hosted the sectional meeting of the American Chemical Society.

- o In April 1982 a workshop on Northern Appalachian Geology was hosted by the University of Maine; 50 scientists attended. A major workshop on physical oceanography of the Gulf of Maine involving 35 scientists was held in July 1982; also two distinguished scientists from Europe, Dr. John Simpson and Dr. Gunnar Kullenburg, have been visiting researchers at Bigelow Laboratory.

8. The quality of the science and engineering faculty in participating institutions has been improved.

For example:

- o The University of South Carolina has hired three new faculty. Dr. James Marshall, a noted synthetic organic chemist, has moved from Northwestern University. Dr. Marshall's record with NSF is 13 awards and 1 declination. He currently has a $223k NSF grant and a $252k NIH grant. Dr. Fred Myhrer, an internationally known physicist from Norway, has been hired. Dr. Jerrold Griggs, an NSF funded mathematician from the University of Hawaii is moving to the University of South Carolina. With these additions, the quality of the graduate student applicants has increased. Additionally, 3 top flight physicists were hired by the university.

- o Clemson University hired two new senior faculty. Dr. Leslie Grady from Purdue has been hired as the Chairman of Environmental Engineering. Dr. Charles Jennett is the Dean of Engineering. Both have excellent track records with NSF.

- The University of Maine has hired two nationally known earth scientists.
    - Dr. Edward Decker moved from Los Alamos; he is a geophysicist and has had NSF and DOE support continuously since 1970.
    - Dr. Charles Guidotti is a Harvard trained petrologist; he moved from the University of Wisconsin; he is an active NSF grantee.

The NSF record for the newly hired faculty in Maine is 19 awards, 2 declinations, and 1 withdrawal.

- The University of Arkansas, Fayetteville recently acquired Dr. Boris Schein, a noted Russian algebraist.
- Arkansas has added 24 new faculty since October 1980, and EPSCoR has been cited as a major factor in attracting the new appointments.

9. Community and industrial involvement in local efforts to improve research has increased and provided some very beneficial results.

For example:

- The initial chairman of the Maine ad hoc committee (an industrialist) has been appointed as a trustee of the Bigelow Laboratory.
- A Surface Science Laboratory has been formed in physics at the University of Maine as a consequence of staff involvement in the Experimental Program planning process.
- West Virginia University has established joint research efforts with the Union Carbide Technical Center in Charleston.
- Every EPSCoR committee has representatives from industry and state governments.
- Two members of the industrial community on the MONTS ad hoc committee have contributed company funds in support of MONTS.
- In both Montana & Arkansas the program has contributed to the creation of "Governors Science and Technology Boards."

10. Internal communication between scientists, administrators, legislators and the community has been improved.

For example:

- State-wide planning committees in all states are continuing through the implementation period.
- South Carolina has established three science and engineering subcommittees to encourage and support participant investigators in their efforts to become competitive. Additionally, the program has fostered joint colloquia in mathematics, using outside speakers, between the University of South Carolina and Clemson University in Discrete Mathematics.
- The state committee in Maine has used the Experimental Program as a vehicle to go beyond specific program concerns and address questions relating to the growth of, and attitudes about science in general in the state of Maine. Discussions have included the adequacy of the salary structure at UMO and the need for a Maine academy of sciences.
- In West Virginia the central administration is meeting regularly with program participants to discuss barriers to research competitiveness and progress being made.
- In Arkansas, state-wide research groups have been formed in laser physics and mathematics.
- In Montana, the Commissioner of Higher Education, a physicist, is the Chairman of the EPSCoR Supervisory Committee.
- Two smaller schools in Montana, Eastern Montana and Montana Tech., are contributing $50k each to participate in the MONTS program. No NSF funds are involved.
- In Maine, the university at Orono and Bigelow Laboratory for Ocean Sciences are working together to develop a strong research team centered on understanding the physical and biological properties of the Gulf of Maine. These new linkages are being institutionalized and should continue beyond the NSF grant period.

11. Young scientists are being provided with "local" role models and with assistance in developing research proposals.

For example:

- o In Montana, Gary Strobel of Montana State University makes periodic visits to grantees, counsels and encourages them, resolves conflicts and problems, helps in idea and proposal development and helps connect investigators with experts in their field. The MONTS-PD function is "state-wide" and not limited to a single university. Career goals, manuscript preparation, grant management/planning, and even personnel problems that may play some role in creative thinking are discussed with MONTS grantees.

12. Proposals from EPSCoR scientists are on the increase.

For example:

- o All MONTS participants are required to submit a proposal to an outside agency within 16 months of obtaining state support. The "amount requested" of outside agencies from participants increased from $600,000 in 1982 to $15.8 million in 1983. To date $3 million has been awarded.
- o In South Carolina, 76 faculty were targeted for development; collectively in 1981 they had 4 funded proposals. By 1983 they accounted for 49 funded proposals.

13. Failure under EPSCoR has had some unexpected results.

For example:

- o In South Carolina, two solid-state physicists denied support by EPSCoR, developed a proposal to NSF Solid-State Chemistry program and were funded.
- o At least 5 major proposals that received low priority rankings from the outside peer reviewers and the MONTS Science Evaluation Committee were eventually submitted to NSF and NIH (regular programs) and funded. The collective sums of these grants is approximately $600,000. This fact nicely illustrates another aspect of MONTS that was not originally anticipated. That is, a number of individuals would improve their proposals (after the MONTS review) and independently submit them to national funding agencies and be successful.

14. Equipment upgrades have taken place, making participants competitive in their field.

For example:

- At Clemson University a thermal-fluid science research facility with associated instrumentation has been developing, making them competitive in heat transfer.
- At the University of South Carolina, Columbia, the acquisition of a GC Mass spectrometer contributed greatly in attracting a nationally recognized organic synthetic chemist. Also the development of a state-of-the-art quantitative social science research laboratory at the University of South Carolina resulted in 3 NSF research grants in the social sciences.
- The need for equipment has been a continual problem in the research community in Montana. Since MONTS began in 1980 several exciting developments have occurred - the most outstanding of which is the acquisition of four major equipment grants from regular NSF programs in the Department of Chemistry at MSU. Two of these grants purchased 2 state-of-the-art mass spectrometers, making MSU extremely competitve in chemical characterization via the enormously vast new technologies of mass spectrometry, i.e., FAB. In addition, the department acquired funding for a 250 mhz NMR with multinuclear probe capabilities. In late May, another NSF award from the Chemistry Division was made for a computerized X-ray spectrometer. In all cases, one or more MONTS grantees were involved in the preparation of these proposals. All proposals are independent of the MONTS money.
- Lack of state-of-the-art equipment was a major barrier identified by Arkansas in the EPSCoR planning phase; of the total $2.6 million provided by NSF about $1.2 million was used for equipment, significantly enhancing their capability in such areas as laser sciences, chemistry, aquatic biology, genetics and molecular biology, and the neurosciences.

Current Status and Future Plans

The Experimental Program is evaluating continuation proposals from the five states totalling around $2.5 million. Peer review of the science and engineering components is being conducted and site visits to participating schools are being done to assess progress and the commitments of the states to the program goals. Awards are expected to be made in late December 1983. These actions will provide the final increment of support for years 4 and 5 of the 5-year Phase B Implementation award to each state. Continuation of the improvement achieved under the NSF award is expected to be sustained by the participant states.

There are no additional funds available for EPSCoR and no plans to initiate similar efforts in other states at this time. As the program is phased out, competitive research efforts resulting from EPSCoR will be funded in FY 1985 and beyond through the Foundation's research programs in each scientific field.

The review of EPSCoR continuation proposals is in progress and not all reviews have been completed; 36 proposals are being considered.

The following are excerpts of comments made by NSF Research Program Directors about some of the EPSCoR proposals. They are illustrative of many others.

- About a physics project in Montana:

  > "It is a pleasure to recommend funding for..... His research is certainly competitive with work normally funded...and would probably rank in the top quarter of this program."

- About a chemistry project in Montana:

  > "Although   X   has been unsuccessful in two recent attempts...I feel he has the potential to prepare a successful one...I strongly recommend continued funding."

- About a chemistry project in South Carolina:

  > "Seven of the original participants...appear to have become nationally competitive...In view of the very good progress to date...it is recommended that continued support be provided."

- About a chemsitry project in West Virginia:

> "research supported....has progressed as originally envisaged and there is a clear indication that objectives will be met and significant results of both fundamental and practical importance will be produced."

- About an ecology project in Arkansas:

> "Overall the P.I. has made excellent progress....The work is being published as rapidly as can be expected....evolution of the P.I. towards national competitiveness is occurring as quickly as could be expected."

- About a neuroscience project in Arkansas:

> "All investigators have published....perhaps of greater importance in the context of this EPSCoR continuation proposal, is that a total of eleven grant proposals have been submitted....my sense is that the overall level of productivity of this group has increased significantly."

- About a physics project in Arkansas:

> "This proposal makes an impressive case for the EPSCoR program....I would rate the bulk of it (this proposal) as competitive in the sense of NSF and highly recommend further renewal."

It should be noted that the Foundation recently established an Outreach effort to provide more information to prospective grantees about NSF programs and opportunities. This effort grew out of our experience with EPSCoR states. In connection with this effort, the Foundation is sending a site visit team to Idaho to convey information about NSF in general and to discuss with university administrators, faculty, and representatives of industry and state government the results of the EPSCoR program, the role that strong support by state government has played in the success of the program, and the potential use of existing EPSCoR improvement plans as models for similar efforts.

Through this means, we would hope to stimulate ideas for research proposals and to help Idaho's scientists and engineers improve their capabilities to compete for NSF funds. This is in keeping with our longstanding policy that capable people at institutions in all parts of the Nation be encouraged to propose their research ideas for consideration in an equitable competitive process that leads to funding the most scientifically meritorious work, wherever it may take place.

If this visit is valuable to Idaho, we may consider conducting other such visits to states whose scientists and engineers have been relatively less successful in competing for Federal R&D funds.

Further, progress under the program will be evaluated to determine the actual success of the program in terms of increasing the Federal R&D funds awarded to each state via the competitive peer review system.

PROGRAM DETAILS

CONCEPTS

- The program concepts were approved by the NSB in January 1978.
- Arkansas, Maine, Montana, North Dakota, South Carolina, South Dakota, and West Virginia were selected to participate in the Phase A planning process, principally on the basis of their relatively low funding from NSF and other Federal sources.
- The program objectives are to: (1) improve the quality of science and engineering in participating states, and (2) increase the ability of scientists and engineers in participating states to compete successfully for Federal funds through the accepted peer reveiw system.
- States were to select the target science and engineering areas and the strategies for improving their basic research effort.
- The target scientists and engineers and the research problems posed had to be judged "good" or "better" by national standards with the potential to acheive excellence within the five-year project period.
- Scientific areas and individual scientists and engineers already deemed "nationally competitive" were excluded from receiving research support but could act as mentors for targeted faculty.
- Up to $3 million over a five-year period could be requested by each state as partial support for their implementation plan.
- NSF funds were to be used to foster higher quality science not improved grantsmanship.
- A strong state and institutional commitment to the project was essential; hence, extensive cost sharing was required.

Planning Process

- Through a consensus process NSF asked five to six people within each state to serve on an ad hoc state committee.
- State committees were made up of key scientists, administrators and prominent industrial and community leaders.
- Each committee received $125,000 to do a nine month study of the quality of current research efforts and to develop a five-year plan for making a significant improvement in that quality. Program Staff worked with states; (1) to help convey NSF objectives, and (2) to insure that the study decisions were based on quality considerations.
- Nationally recognized scientists from outside participant states were used to assess "scientific quality" relative to national standards.
- The planning grants yielded seven five-year research improvements programs which were submitted to NSF in January 1980.
- Plans ranged in size from $4 to $8 million; only $3 million could be requested of NSF.

Review of Proposals

- Proposals were reviewed between February 1980 and April 30, 1980.
- Experimental Program proposals contained two sections. Section I discussed the overall five-year plan, the cost sharing commitment and plans for maintaining the improvement; Section II described separate component scientific projects constituting the overall plan.
- Nationally recognized scientists and engineers helped determine the scientific merit and potential of the component projects to achieve excellence by national standards.
- Site visits were conducted to determine the quality of the overall plan, its revelance to state needs, and the strength of the state and institutional commitment to the project and its maintenance.

Review Results

- North Dakota and South Dakota were declined; Arkansas, Maine, Montana, South Carolina, and West Virginia were funded.
- Only projects with the potential to meet regular NSF programs standards by the end of the five-year period were supported. Of the 134 components included in the seven state plans, 68 were supported in five states.
- Five five-year continuing grants ranging in size from $2.5 to $3 million were awarded in October 1980.
- The total commitment for the five awards was $12.8 million; $5.3 million has been obligated.

Implementation Plans

- All five plans support individual scientists; grantsmanship activities are not funded with program funds.
- Scientist and areas included in the plans underwent vigorous peer review prior to inclusion. (eg. Montana peer reviewed over 100 proposals before selecting 38 finalists, South Carolina peer reviewed 32 and submitted ten.
- Sixty-eight component projects are funded; about a 50% success ratio.
- The distribution of the funds by NSF research areas is: 36% MPS; 29% BBS; 25% AAEO, and 11% ENG.
- Chemistry had the most projects and received the most money.

Arkansas

- Requests $3 million and commits $5 million in cost sharing for the project
- Multiple improvement strategies are used;
- Major effort is at Fayetteville and Medical Campus at Little Rock;
- Program supports emerging areas in molecular structures, laser physics and aquatic ecology at Fayetteville and neurobiology and genetics at the Medical Science Campus in Little Rock.
- Four individual research projects in chemistry, biochemistry, and cell biology at smaller schools are supported.
- Emphasis is on upgrading equipment (1.2 million of 2.6 million total NSF commitment) and technical support personnel ($1 million).

- All indirect costs are waived and faculty release time is contributed.

Maine

- The program is targeted at Earth and Marine Sciences.
- These areas were considered by the state to be strong but with weak links: Experimental Program is directed at strengthening these links.
- The Marine Science Program is a joint effort between Bigelow Laboratory and the University of Maine (Orono); research is being conducted on nutrient regeneration in the Gulf of Maine.
- The Earth Science Program focuses on understanding the Eastern segment of the Appalachian orogen.
- Emphasis is placed on hiring new faculty and other technical personnel to augment existing staff and develop a critical mass in each area.
- $1.6 million dollars cost sharing will be provided

Montana

- The program focuses on existing talent in the state.
- The program supports 31 individual researchers. Projects were chosen from 112 proposals submitted to the state committee during the planning process.
- Participants are considered to have greatest potential to become competitive on a national level; 11 scientific areas are funded.
- The program is being coordinated and managed by MONTS office at Montana State University.
- The state is to provide $1.5 million cost sharing to MONTS office to support faculty development and travel, graduate student stipends instrumentation and a guest lecture program.

South Carolina

- The program focuses on ten areas determined to be sufficiently strong to achieve national recognition within five-years.
- Target areas were selected after considering 32 proposals from the four graduate level institutions.
- Support is provided for improving basic research in: (1) thermal science, bioengineering, environmental engineering, and mathematics at Clemson; (2) physics, chemistry, mathematics, and social and behavioral sciences at the University of South Carolina, and (3) statistics at the Medical University of South Carolina.

- All indirect costs have been waived and the state is to provide another $2.2 million in cost sharing.
- Seventy percent of the NSF funds are used for personnel costs including faculty release time, the hiring of new faculty and post docs, and graduate student stipends.
- Science and engineering subcommittees comprised of competitive South Carolina scientists have been established to help targeted scientists.

West Virginia

- Program focuses on 20 young scientists in eight already strong departments and strives to develop a critical mass.
- NSF is providing release time, graduate students and post docs, and equipment to increase the research productivity of targeted faculty.
- Areas supported include: physics, geology and geography, chemistry, psychology, mathematics, electrical enineering, and the Reginal Research Institute at West Virginia University and psychology at Marshall University.
- Close to $1 million is to be provided in cost sharing.

Experimental Program to Stimulate Competitive Research
Phase B Implementation Plan in Arkansas

The State of Arkansas will use various methods, ranging from individual research initiation activities to the development of inter- and intra-university centers and institutes to strengthen selected basic science areas. Special emphasis will be placed on acquiring research instrumentation and providing researchers with sufficient release time to do research.

The NSF's commitment to the project is $2.7 million; this award for $1,216,936 supports the first year of a five-year program.

Dr. Charles A. Leone, vice-president for research and graduate studies, University of Arkansas System will be project director. Policy guidance and direction will be provided by the State-wide Experimental Program to Stimulate Competitive Research Committee.

Staff support to the committee and Dr. Leone will be provided by Ms. Anne Gibbons George, who will be project manager.

The program is the product of a nine-month assessment conducted by the Arkansas Experimental Program to Stimulate Competitive Research Committee.

Two major state-wide co-operative projects are being conducted. A center for mathematical research at the University of Arkansas, Fayetteville, will be established to help develop the research competence of faculty in five institutions. Scientists from the Fayetteville campus, the University's Graduate Institute of Technology and the Medical Sciences Campus at Little Rock will participate in a research program which will apply lasers to basic science problems. Another project in aquatic ecology fosters a joint research program between Henderson State University at Arkadelphia and the University of Arkansas at Fayetteville.

Three intra-institution projects are included in Arkansas' plan. Structural chemistry will be supported at the University of Arkansas at Fayetteville; and neurobiology and genetics at the University of Arkansas Medical Science Campus in Little Rock. Four projects proposed by individual investigators are included in the plan. They involve scientists at Hendrix College, the University of Arkansas at Little Rock and Arkansas State University at Jonesboro. The science areas are chemistry, biochemistry and cell biology.

Listings of committee membership and specific projects, scientists and universities participating in the Arkansas plan are attached. The University of Arkansas at Fayetteville will serve as fiscal agent for the program.

NATIONAL SCIENCE FOUNDATION
EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH
FY 1980-81
IMPLEMENTATION AWARDS

Ad Hoc Committee Chairman	Fiscal Agent
LEONE, Charles A. Vice-President for Research and Graduate Studies University of Arkansas System	University of Arkansas
BIXLER, Harris J. President AVCO - Everett Research Laboratory	University of Maine, Orono
DAYTON, Irving E. Deputy Commissioner for Academic Affairs The Montana University System	Montana State University
DURIG, James R. Dean, College of Science and Mathematics University of South Carolina, Columbia	University of South Carolina, Columbia
THOMAS, John A. Associate Dean West Virginia University Medical Center	West Virginia University

Experimental Program to Stimulate Competitive Research
Arkansas' Phase II Implementation Plan
Component Projects
Year 1

Project Title	Project Leader/Department	Amount
UNIVERSITY OF ARKANSAS, FAYETTEVILLE		
Center for Research in the Mathematical Sciences	Bernard L. Madison Mathematics	$ 35,764
Molecular Structure Program	A. Wallace Cordes Chemistry	$322,675
The Application of Lasers to Problems in the Basic Sciences	Gregory J. Salamo Physics	$481,735
Aquatic Ecology Studies	Arthur V. Brown Zoology	$ 40,369
UNIVERSITY OF ARKANSAS, MEDICAL SCIENCES CAMPUS		
Neuroscience Program	Edgar Garcia-Rill Anatomy	$111,000
Genetic Biology Program	James S. Norris Medicine and Physiology (JSN)	$ 96,015
UNIVERSITY OF ARKANSAS, LITTLE ROCK		
Modular Rapid Kinetics Instrumentation/Measurement of Transients in Specific Biochemical Processes	Robert C. Steinmeier Chemistry	$ 36,127
The Role of Cyclic 3', 5' Adenosine Monophosphate as a Regulator of Growth and Differentiation	Thomas J. Lynch Biology	$ 43,693
ARKANSAS STATE UNIVERSITY		
High Temperature Chemistry of Sulfur-Containing Inorganic Substances	J. Edward Bennett Chemistry	$ 43,014
HENDRIX COLLEGE		
Organochemical Synthesis via Conjugate Additions to Hex-1- [illegible] and Gamma Alkylation of Allylic Alcohols	Thomas E. Goodwin Chemistry	$ 5,744

Experimental Program to Stimulate Competitive Research
Phase B Implementation Plan in Maine

The State of Maine has selected earth sciences and marine sciences as target areas for improvement. Programs are being supported at the University of Maine at Orono and at the Bigelow Laboratory for Ocean Sciences. The NSF's commitment to the project is $3.0 million. This award of $776,999 supports the first year of a five-year program.

Dr. Harris J. Bixler, president of AVCO-Everett Research Laboratory, will be project director. Policy guidance and direction will be provided by the State-wide Experimental Program to Stimulate Competitive Research Supervisory Committee, chaired by Dr. Bixler.

Dr. Frederick E. Hutchinson, acting vice president for academic affairs, will be responsible for the fiscal management of the program and will serve as vice chairman of the Maine Supervisory Committee. Dr. Alton Clark, professor of physics, will direct the day-to-day management of the program.

Maine's plan is the product of a nine-month assessment conducted by the Maine Ad Hoc Committee to Stimulate Competitive Research, chaired by Dr. Bixler. Five component projects are being supported by this award. One project at the University of Maine, Orono, mobilizes a group of scientists and focuses their efforts on establishing a basic understanding of ancient mountain chains. To strengthen the overall program, new specialists will be hired.

Another effort involves the addition of a coastal sedimentologist to the earth sciences faculty. Proposed studies of suspended sediment are of interest to the state's coastal industries.

A three-person research team will be established to conduct a study focused on recent crustal deformations along the Maine coast. The research findings will be important to the state in the selection of safe sites for industrial facilities.

A cooperative project between the University's Darling Center for Marine Research and Bigelow Laboratory will enhance each organization's capability to study the processes which control the regeneration of nutrients in shallow waters. Problems of nutrient regeneration along the coast and in the Gulf of Maine are especially important to the state's fishing industry. Closely tied to the nutrient regeneration project will be a study of the interaction between physical mixing processes and biological production in the water.

Listings of committee membership, specific projects, scientists, and universities participating in the Maine plan are attached. The University of Maine, Orono, will serve as fiscal agent for the overall plan.

Experimental Program to Stimulate Competitive Research
Maine's Phase B Implementation Plan
Component Projects
Year 1

UNIVERSITY OF MAINE, ORONO (UMO)

Project Title	Project Leaders
Earth Sciences Program Implementation Plan	Stephen Norton Geological Sciences

Components	Amount
Applachian Geology	$299,061
Coastal Sedimentology	$ 86,122
Geophysics/Neotectonics	(Begins in second year)

UNIVERSITY OF MAINE, ORONO, AND THE BIGELOW LABORATORY FOR OCEAN SCIENCES (BLOS)

Marine Sciences Program Implementation Plan	Malvern Gilmartin, Center for Ocean Sciences (UMO); Clarice Yentsch, Acting Director for Research (BLOS)

Components	Amount
Benthic Processes Controlling Nutrient Regeneration in Shallow Waters	$ 85,508 (UMO) $ 43,309 (Bigelow)
Interaction Between Physical Mixing Processes and Biological Production in the Water Column	$ 57,991 (UMO) $165,686 (Bigelow)

Experimental Program to Stimulate Competitive Research
Phase B Implementation Plan in Montana

The Experimental Program Plan in Montana focuses on nurturing the talents of individual research scientists.

Within the state the program is known as MONTS (Montanans on a New Trac for Science). Its goals are to bring more individuals into the national competitive science scene, to create more research spirit and to enhance research-related activities across the state.

The NSF's commitment to the project is $2.4 million; this award for $827,213 supports the first of a five-year program.

Dr. Irving E. Dayton, deputy commissioner for academic affairs, for the Montana University System, will serve as co-project director and chairman of the State-wide Experimental Program to Stimulate Competitive Research Ad Hoc (MONTS) Committee which will provide policy guidance and direction to the project. Dr. Gary A. Strobel, professor of plant pathology, will serve as the co-project director and principal administrator of the project and will provide day-to-day direction.

The program is the product of a nine-month assessment conducted by the MONTS Committee. Montana's program includes 11 general areas of scientific endeavor: chemistry, plant biology, microbiology, earth science, physics, animal biology, psychology, sociology, mathematics, engineering and mineralogy.

A total of 31 promising scientists at the Montana State University, the University of Montana and Montana College of Mineral Science and Technology are being given increased opportunities to develop their research competence.

The MONTS plan also will expand the number of seminars and consultant visitations, faculty mini-leaves, release time and travel and will increase the number of graduate assistants.

Listings of committee membership and specific projects, scientists, and universities participating in the Montana plan are attached. The Montana State University will serve as fiscal agent for the program.

Experimental Program to Stimulate Competitive Research
Montana's Phase B Implementation Plan
Component Projects
Year 1

UNIVERSITY OF MONTANA

Project Title	Principal Investigator/Department	Amount
Systematic and Evolutionary Studies of Salvia Subgenus Calosphace Section Uliginosae	Kathleen M. Petersen Botany	$ 28,230
Cardiolipin Metabolism and Lipoteichoic Acid Synthesis in Bacillus stearothermophilus	George L. Card Microbiology	$ 22,826
The Origin, Distribution and Economic Potential of the Cu-Ag-Bearing Carbonate Units of the Eastern Late Precambrian Belt Basin, Montana	Ian M. Lange/Johnnie N. Moore Geology	$ 35,002
Precambrian Stratigraphy, Sedimentology and Tectonics of Parts of the Belt Basin, Montana and Idaho	Don Winston Geology	$ 24,752
Physical Properties of the Lower Continental Crust: A Study Based on Exposed Cross-Sections of the Deep Crust	David M. Fountain Geology	$ 51,800
Evolution of Differential Expression of Duplicate Loci in Salmonid Fish	Fred W. Allendorf Zoology	$ 31,504
Children's Television Commercials, Food Consumption, and Health	D. Balfour Jeffrey Psychology	$ 28,696
The Behavior of Iron Deficient Monkeys	David A. Strobel Psychology	$ 20,808
A Control System Approach to Behavior	Laurence H. Berger Psychology	$ 40,931
Longitudinal Study of Sex Roles, Work Roles, and Fertility	William H. McBroom/Fred W. Reed Sociology	$ 25,908
Study of Volterra Integral and Integrodifferential Equations	Stanley I. Grossman Mathematics	$ 11,378
Local Extrema in Infectious Disease Incidence Curves	W.R. Derrick/F.J.S. Wang [illegible]	$ 19,015

MONTANA STATE UNIVERSITY

Project Title	Principal Investigator/Department	Amount
High Pressure-High Temperature Silicate Equilibria	Reed A. Howald Chemistry	$ 29,400
Synthetic Methodology via Molecular Rearrangement	Bradford P. Mundy Chemistry	$ 30,177
Low-Temperature Luminescence of Cytosines in Single Crystals and Shpolskii Matrices	Patrik R. Callis Chemistry	$ 25,329
Molecular Basis of Serological Interrelationships Among Coronaviruses	Clifford W. Bond Microbiology	$ 24,920
Functional and Biochemical Studies of Ly-5 Antigens	Sandra Ewald Microbiology	$ 62,358
Search for Parity Violation in Atomic Hydrogen	R.T. Robiscoe Physics	$ 27,061
Thermodynamic Properties of Competing-Bond Magnetic Models	George F. Tuthill Physics	$ 32,775
Plant Growth Hormone Effects on Developing Insect Cells	Saralee N. Visscher Biology	$ 56,356
Origin, Regulation and Function of Intestinal Mast Cells	Patricia K. Crowle Biology	$ 17,229
Parallels Between Motor and Sensory Function of the Spinal Cord	James A. McMillan Biology	$ 19,409
Memory Processes and Duration Experiences	Richard A. Block Psychology	$ 17,328
Bayesian Estimation of a Finite Population Total when there is Nonresponse	Evan P. Smouse Mathematical Sciences	$ 12,941
Fracture Propagation in Snow	Robert G. Oakberg Civil Engineering	$ 26,415

MONTANA STATE UNIVERSITY CONTINUED

Project Title	Principal Investigator/Department	Amount
Investigation of Factors Controlling the Interchange of Surface and Groundwater with Application to Simulation Modeling	A.B. Cunningham Civil Engineering	$ 8,703
Hydrodynamics and Optimization of Air Scour During Backwash	A. Amirtharajah Civil Engineering	$ 35,562

MONTANA COLLEGE OF MINERAL SCIENCE AND TECHNOLOGY

Project Title	Principal Investigator/Department	Amount
Direct Leaching of Zinc Sulfide and Zinc Flotation Concentrate with Copper Catalyst	Hsin-Hsiung Haung Metallurgy and Mineral Processing	$ 21,220

Experimental Program to Stimulate Competitive Research
Phase B Implementation Plan in South Carolina

The experimental program plan in South Carolina includes nine component research projects and will involve investigators at the University of South Carolina, Clemson University, the Medical University of South Carolina and the College of Charleston. The NSF commitment to the project is $2.5 million; this award of $502,396 supports the first year of a five-year program.

Dr. James R. Durig, Dean, College of Science and Mathematics, University of South Carolina at Columbia, will be the project director. Policy guidance and direction will be provided by the State-wide Experimental Program to Stimulate Competitive Research Management Committee, chaired by Dr. Durig.

The program is the product of the nine-month assessment conducted by the South Carolina Ad Hoc Committee to Stimulate Competitive Research.

Projects will be undertaken in engineering, chemistry, physics, mathematics-statistics and in the social and behavioral sciences. At Clemson University, programs are being supported in energy conservation and heat transfer; bioengineering, specifically in the area of bone mechanics; and in understanding and solving problems concerning the sources, distributions, effects and control of toxic trace pollutants.

The chemistry and physics programs at the University of South Carolina will be strengthened through faculty development and the addition of major research equipment. Three integrated projects are aimed at strengthening the areas of discrete mathematics, mathematical structures and statistical theory at Clemson University, the University of South Carolina and the Medical University of South Carolina. An expanded colloquium and visiting scientists program will be established to increase the interaction of South Carolina's mathematicians with leading researchers.

The University of South Carolina's social science and behavioral laboratory will be developed to enhance existing and proposed social and behavioral sciences research.

Listings of committee membership and specific projects, scientists, and universities participating in the South Carolina plan are attached. The University of South Carolina at Columbia will serve as fiscal agent for the program.

Experimental Program to Stimulate Competitive Research
South Carolina's Phase B Implementation Plan
Component Projects
Year 1

UNIVERSITY OF SOUTH CAROLINA, COLUMBIA

Project Title	Project Leader/Department	Amount
Stimulation of Competitive Research in Chemistry	Ronald R. Fisher Chemistry	(Begins in second ye
Research Improvement Project in Nuclear, Fundamental, Theoretical, and Solid State Physics	Frank T. Avignone, III Physics and Astronomy	$ 86,612
A Program to Stimulate Competitive Research in Discrete Mathematics	William T. Trotter, Jr. Mathematics, Computer Science, and Statistics	$ 15,000
Development of the Social and Behavioral Sciences Laboratory into a Major Research Support Facility	David J. Cowen Social and Behavioral Science	$ 65,940

MEDICAL UNIVERSITY OF SOUTH CAROLINA

Project Title	Project Leader/Department	Amount
Statistical Theory for Nonlinear Dynamical Systems with Singularities	M. Clinton Miller, III Biometry	$ 64,700

CLEMSON UNIVERSITY

Project Title	Project Leader/Department	Amount
Development of a Capability for Basic Research in Thermal Science	Eugene H. Bishop Mechanical Engineering	$ 66,414
The Mechanical Properties of Bone: A Comparative Study in Animals and Man	Francis W. Cooke Interdisciplinary Studies	$ 54,822
Environmental Engineering Chemical Systems: Sources, Fate, and Control of Toxic Trace Pollutants	Alan. W. Elzerman Environmental Systems Engineering	$ 62,811
A Plan for Improving Competitiveness of Mathematical Sciences Research	John D. Fulton Mathematical Sciences	$ 65,904

Experimental Program to Stimulate Competitive Research
Phase II Implementation in West Virginia

The Experimental Program Plan in West Virginia focuses primarily on the development of individual researchers having the potential to become nationally recognized in their respective scientific and engineering areas.

The NSF's commitment to the project is $2.5 million; this award for $602,501 supports the first year of a five-year program.

Dr. John A. Thomas, associate dean, West Virginia University Medical Center, will serve as a project director. Policy guidance and direction will be provided by the State-wide Experimental Program to Stimulate Competitive Research Advisory Committee chaired by Dr. Thomas.

The committee and Dr. Thomas will be assisted by Ms. Martha S. Reinhardt, who will serve as project co-ordinator.

The program is a product of a nine-month assessment conducted by the West Virginia Experimental Program to Stimulate Competitive Research Advisory Committee.

The Advisory Committee strategy is two-fold: to provide direct support to promising individuals for research and to augment this support with special activities which would accelerate their attainment of national competitiveness. This will include supporting specialized colloquia, seminars, and symposiums; acquiring specialized multi-user equipment, and coordinating efforts to recruit new faculty.

West Virginia's five-year plan supports 20 investigators located in the Departments of Physics, Geology and Geography, Chemistry, Psychology, Mathematics, Electrical Engineering, and the Regional Research Institute at the West Virginia University and in the Psychology Department at Marshall University.

Listings of committee membership and specific projects, scientists, and universities participating in the West Virginia plan are attached. The West Virginia University will serve as fiscal agent for the program.

Experimental Program to Stimulate Competitive Research
West Virginia's Phase B Implementation Plan
Component Projects
Year 1

WEST VIRGINIA UNIVERSITY

Project Title	Principal Investigator/Department	Amount
Multiport Coupling with Recursive Adaptive Noise-Cancelling in the Frequency Domain	Wasfy B. Mikhael Electrical Engineering	$ 44,725
Reconstructive Imaging Incorporating Refraction, Diffraction, and Depolarization	Herman W. Hill/Constantine A. Balanis Electrical Engineering	$ 43,890
Size Distribution of Ultrasonically Atomized Liquid Droplets -- Acoustic and Electrostatic Effects	Mark A. Jerabek Electrical Engineering	$ 43,452
Responsive Structure, Response Strength, and Response Independent Reinforcement.	Kennon A. Lattal Psychology	$ 26,374
Electron Paramagnetic Resonance and Structural Studies of Bis(Cyclopentadienyl) Metallacyclic Complexes	Jeffrey L. Petersen Chemistry	$ 54,513
Unusual Deprotonation Reactions in Metal Chelates	Robert S. Nakon Chemistry	$ 10,846
Dynamics of Polar Excited Species	William Cherry Chemistry	$ 17,291
Purchase of Varian E-109 EPR Spectrometer and Accessories	Nar S. Dalal/Jeffrey L. Petersen/ Stephen E. Stein Chemistry	(Begins in second year)
Multistability in Chemical Systems	Kenneth Showalter Chemistry	$ 42,810
Certain Qualitative Properties of First and Second Order Functional Differential Equations	Samuel M. Rankin/James H. Lightbourne Mathematics	$ 22,641
Partial Differential Approximant Analysis of Multi-Critical Points Series	Martin V. Ferer Physics	$ 24,728
Direct Evaluation of Models for Polymer Dynamics in Dilute Solutions	Milton E. McDonnell Physics	$ 56,838

WEST VIRGINIA UNIVERSITY CONTINUED

Project Title	Principal Investigator/Department	Amount
Single-site Phase Velocity Measurements in West Virginia and Virginia	Richard T. Williams Geophysics	$ 20,941
Water Service: An Analysis of the Cost Impact	Patrick C. Mann Regional Research Institute	$ 48,003
The Measurement of Agglomeration Economies with Productivity and Amenity Effects: An Investigation into the Productivity of Cities with Applications	Michael S. Fogarty Regional Research Institute	$ 48,815
MARSHALL UNIVERSITY		
Cross-Situational Consistency: Individual Differences and Situational Determinants	William Schneiderman	$ 23,141

Mr. WALGREN. I had one other area I wanted to explore and I didn't want to take all the time.

Mr. Skeen, do you have anything else you want to pursue right now?

Mr. SKEEN. No.

Mr. WALGREN. Let me go back to the engineering problem Mr. Lundine raised. As I understand it, I think it would be helpful if we could ask how you are trying to define where the Science Foundation has a role and where it doesn't have a role. I noticed in your testimony, Dr. Branscomb, you indicated that "NSF," I quote: "should increase its support for research, education and training and the transfer of knowledge and technology between academia and industry in a variety of areas."

I gather what is going on here—we know that universities and industry are moving strongly—in fact, as I understand it, in view of putting dollars into this problem, there has been specific progress made on that level of our society and that is good. On the other hand, we do believe that industry is going to have this interface in a strong way and if we are to do what may be helpful we are going to have to deal with industry in a very direct way.

And in engineering, my question is are we limiting our involvement with industry, and I don't know that old basic applied or basic versus something industry does best or something like that, really solves the problem. My concern is that it is said that because the National Science Foundation over traditional years, a decade or so, has been so focused on the basic that we didn't get involved in engineering in the way we now look back and understand we probably should have been involved in that discipline, in order to prevent the weakness from developing there that has developed in the educational process in particular. My question is, can we approach this in some practical way that focuses on the Science Foundation's responsibility to assure capability in a way that might allow some of these things to happen that ought to happen, rather than be limited by definitions. And as a layman, I do believe the Science Foundation has a fundamental responsibility to assure a certain capability in the society, regardless of what kind of research is involved in securing that capability. And I wonder whether we are doing enough for the engineering component?

As I understand it, the National Academy of Engineering made specific recommendations, one of which was increasing the number of engineers at policy and program levels in the National Science Foundation. Now, I gather that the result of increasing the presence of engineering personnel on policy making levels in the National Science Foundation would be to bring some of this sort of more practical capability oriented decisionmaking as opposed to perhaps a more ideological basic versus applied. Can you respond to that?

Dr. BRANSCOMB. I would like to answer first and let the Director answer the management question.

First of all, I think you have posed a real issue, so did Mr. Lundine, and I intend to answer it. But I take some comfort as I try to answer it from the fact that there is a pretty broad common view of what this limit ought to be, both among those who are really concerned about the fundamental science and the health of the universities in that perspective, who might be concerned that funds would be improperly diverted to benefit industry and the people in industry who are trying to define the right role for the universities.

I assure you, at least speaking now personally for the company I work for, most companies are not eager to have Government fund research that is aimed at solving the problems that they are trying to solve on a competitive basis.

So, first of all, I think there is a pretty good political consensus from right and left that there is a limit and we ought to define it. The most important pieces of that limit are:

No. 1, I don't believe the Science Foundation should spend significant sums of money in industry. I will make a small footnote that says that, for the cooperative industry university programs, sometimes it is appropriate that some of the grant go to the company. I will certainly make an exception for the small business program, which is a special case. But the money goes to the university.

No. 2, it is very important that the work we fund be absolutely open for all comers to see and know about and get it published. That is the principal protection against having the Government end up funding something that one company wishes to use to the disadvantage of another competitively, for everybody will have access to the research.

Having said that, I think I would like then to say that we are not really imagining that the Foundation would, if you take the discipline of engineering science, whether it be aeronautical engineering, ceramics engineering, civil engineering—we are not proposing that in those disciplines that the engineering research start funding more near-term industry-interesting things. We want to keep that disciplinary engineering research aimed at the forefront, just as the physics and chemistry research is; it is not different, except as an engineering way of doing research is different.

What we are trying to do is really two things. One is to add another dimension of rather fundamental engineering work which happens to relate to engineering systems rather than to the individual investigator pushing the laws of mathematics and physics in an engineering context. So we're talking about manufacturing environments, we're talking about new mathematical concepts for quality management, things of that kind. They are still quite fundamental; it is not solving a specific company's problem, but it is a systems kind of research. I don't think that takes us any further toward that difficult, controversial ground.

Second, as we choose the disciplines to work in, I observe that today engineering research done by small groups of individuals is mostly on problems of engineering that are important to the Pentagon and to other Government programs.

Why? Because that is where engineering support has heavily come from in the past and those are important national problems, and we should continue to do that. But it needs to be balanced by an equal opportunity for the engineers in other disciplines to work on the forefront problems in some exciting areas of engineering in which the universities have had almost no role.

Let me give you an example. In Santa Clara Valley, Calif., often called Silicon Valley, there are a lot of companies that make magnetic storage devices for computers, disk files they are called. In fact, the total employment and revenue from that activity exceeds that from semiconductors. We really ought to call it Iron Oxide Valley, not Silicon Valley.

That is a many billions of dollars a year industry that is employing Americans, and it operates at a level of scientific sophistication that is almost mindboggling. The heads on those disk files are flying 10 millionths of an inch above the surface of a spinning disk and must not ever touch. It is indeed very complex and very intellectually challenging.

And yet, except for a small program at Carnegie-Mellon University, there is no engineering school in America that has a research program on the engineering of magnetic materials and magnetic technologies. The industry got concerned about that and several companies got together and both helped Carnegie-Mellon and put up many millions to start a program at the University of California, San Diego.

Why? Because the industry had gotten out in front of the universities in the technology, and here is a case where you don't send the guy from the company back to the university to get brought up to date. In fact, you send the university person to the company to get brought up to date.

So there is a company interest. In this case it has been evidenced by real investment, there is also a national interest to allow the engineering community to get into the exploratory, far-out part of the technologies which we know are important in our economy. It is not that they are going to develop disk files in those universities; I hope they don't. It is that they would be permitted to make proposals for exploring magnetic science and technology problems at the very forefront of technology where you need the very latest research of science to make progress.

It is exciting work and it would obviously have benefit to the economy.

Dr. **Knapp**. I think our proposal for 1985 in fact addresses just this point in our multidisciplinary research centers for engineering. This particular example is a case that would be a possible candidate as a multidisciplinary research center at a university for bringing together mechanical engineers, electrical engineers, physicists, chemists, a wide range of scientists and engineers, to work on a problem of great importance to the country and to technology. It would not be applied research in the sense that the kind of thing they would do would be to understand how to build a better disk file; it would be the very basic research of understanding how signals are recorded in iron oxide, how are they extracted from it, how tight a density, how closely packed can that information be?

The fundamental processes that go behind that particular industry, as Dr. Branscomb says, are just now being addressed for the first time in university centers such as at Carnegie-Mellon.

Dr. **Branscomb**. We have analogous problem in computer science. In 1965 and 1966, when there was a major exploration of activity in the computer industry, computers that were developed, there was not a single Ph.D. in computer science involved in the thousands of engineers that developed those computers.

Why? There was no such thing as a Ph.D. in computer science. Today, after a lot of investment of public funds and some private funds, we have lively and effective computer science departments. The people that the industry now hires with masters and Ph.D. degrees from those computer science departments can run rings around the folks that designed those computers in the 1960's, and it has given the industry another whole lift.

It is giving the universities the opportunity to respond to changing technological times by evolving into new disciplines that explore new areas that we are really talking about. The inelasticity of the system and technological change is very great in universities.

Mr. WALGREN. How will the engineering community respond? Have you had feedback from them?

Dr. KNAPP. They have been very heavily involved in designing the program. We have had a number of meetings with people in the National Academy of Engineering. We asked the Academy of Engineering to convene a meeting in January, 5. I was out of town, but Dr. Nicholson, the Acting Deputy Director, presented some of our views. Dr. Keyworth talked to the Academy of Engineering about the possibilities for this program. They have been heavily involved in choosing what kind of a program engineering needs to take upon itself and this next step in effectiveness in universities, and we think they are well behind it.

The vast majority of the engineers who understand this program and who have helped us with it are really extremely excited about it and its potential.

Mr. WALGREN. Let me raise one other subject, and that is with the policy research analysis group. And this—I suppose there is always a balance between long-range and short-range policy research that you try to do. It has been said that the Science Foundation has been drawn into some of the short-term, almost political controversies to solve problems for other agencies of the administration, EPA and others.

Do you see that as diminishing the long-range planning aspects or analytical abilities of the organization?

Dr. KNAPP. No, I don't. I think there is a certain amount of misunderstanding of what we have been doing with our PRA group at the Foundation. I know there was an editorial in Science magazine which indicated a certain amount of worry in the community about that. We still have our basic grant system for long-term policy research, which is administered by the PRA in place, and it is not being diminished in any sense; it is going forward.

What we are doing is increasing our ability to do policy analysis within the Foundation for the OMB and the National Science Board on a relatively short-term basis.

Now, the policy research arm of the Foundation was formed when Dr. Stever was both the science advisor to the President and the Director of the NSF. That is its synthesis, and this ability to do short looks at policy problems and try to get their fiscal impact has been a characteristic of this group ever since its formation many years ago. It has always done this.

We have tried to make it more responsive to a wider range of agencies in the Government, in particular to the National Science Board and the Director of the National Science Foundation. We are taking much more interest in their ability to help us with our policy questions.

But as for diminishing the long-term policy analysis that is done through grants and contracts to university groups, that is as big as it ever was and isn't to be diminished.

Dr. **Branscomb.** In fact, the question you raise bears directly on one of your earlier questions this morning. That is, that the way the Board and the Director work together in policy work. The Board has chosen to rely upon the staff of the Foundation as its support arm for doing the staff work as to policy.

Our June meetings, where we focus on policy issues, are the result of 3 or 4 months of very heavy staff work by the experts in the Foundation. The documents and studies that we depend upon are the staff studies. Sometimes those are appropriate to be done in the directorates if the issue lies within their domain, but very often in the broader scale questions, like Mr. Brown's question to us last year about science and engineering information policy, the Board needs an instrumentality within the Foundation to help us be responsive and, in fact, we are using PRA right now to help us explore that set of issues.

Mr. **Walgren.** Well, on behalf of the committee, let me thank you both for coming, and we will look forward to seeing Dr. Knapp next week.

Dr. **Branscomb.** Thank you very much.

Dr. **Knapp.** Thank you.

[Whereupon, at 11:38 a.m., the subcommittee was adjourned subject to the call of the Chair.]

1985 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

THURSDAY, FEBRUARY 9, 1984

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to call, at 2 p.m., in room 2325, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Gregg, Boehlert, Dymally, Reid, McGrath, and Skeen.

Mr. **Walgren**. The subcommittee will be in order. This afternoon we will continue with our National Science Foundation authorization hearings for fiscal year 1985.

Last Friday Dr. Knapp and Dr. Branscomb gave the subcommittee an overview of the Foundation's fiscal year 1985 budget, and we had a chance to discuss a number of issues in a general way.

We would like to ask more questions today.

We are happy to have Dr. Knapp with us again, accompanied by the Assistant Directors. We are pleased also to have Dr. Mary Good, Vice Chairman of the National Science Board, with us.

I might mention that we will be having two further days of hearings on the Foundation's budget, February 28 and 29. At that time we will hear the views of scientific and professional organizations, and other nongovernment witnesses.

Now, Dr. Knapp, if you would like to introduce the persons accompanying you and proceed in any way you find most comfortable.

I know we did bring back the film that was shown the other day really because other members were not here then, because it was a difficult schedule day, but I notice Mr. Gregg would like to talk about things more directly than see the film, so we will go into our discussion.

Other members may come that have not seen it but would like to, but for now, we will hold the film.

STATEMENT OF DR. EDWARD A. KNAPP, DIRECTOR, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY ASSISTANT DIRECTORS, NATIONAL SCIENCE FOUNDATION, AND DR. MARY L. GOOD, VICE CHAIRMAN, NATIONAL SCIENCE BOARD

Mr. **Knapp**. I was planning to show the film at the end of my testimony anyway.

We will make a decision at that time.

Mr. Chairman, I would like to start right out.

I am pleased to be here today for the second day of hearings on the administration's fiscal year 1985 budget request for the National Science Foundation.

With me today is Dr. Mary Good, Vice Chairman of the National Science Board, who is here to respond to any questions you may have.

Last Friday I described some of the important scientific questions which this budget will help us address, and I discussed two major policy issues that my colleagues on the National Science Board and I regard as deserving special attention.

Today I would like to discuss research instrumentation, an issue which affects nearly every program in the Foundation. I will then return to two issues which Dr. Branscomb raised last week; supercomputers and science education.

INSTRUMENTATION FOR EXPERIMENTAL RESEARCH

Advances in science and engineering result from the interplay between experiment and hypotheses. Successful experiments stimulate new hypotheses. New hypotheses in turn require further experimentation, or observation, in sciences like astronomy. Both experimentation and observation involve measurement, and thus advances in science and engineering come to depend on new and better instruments.

Conversely, the instruments themselves are often products of science and engineering. Many indispensable instruments today—lasers, spectrometers, electron microscopes, and computers, for example—were made possible by basic research in science and engineering.

This process is continuous. Advances in technology make possible the tools needed for advances in fundamental research, and fundamental research makes possible the technologies required for new generations of scientific instruments.

The process leads to a practical problem, however. Scientific instruments become obsolete rapidly. They need to be replaced regularly, not because they are worn out, but rather because more capable instruments simply make them ineffective.

For example, the electron microscope of the 1960's cost perhaps $100,000 and could see an object smaller than 1 millionth of a meter, or something between 1,000 and 10,000 angstrom units. It was the premier instrument of that time. In 1970 the scanning transmission electron microscope improved this resolution by a factor of 1,000; it could resolve objects only 5 angstroms across.

Further improvements may allow resolution that is 10 times better than that, but the cost is also higher. The new microscope will cost at least $1 million.

The scientific progress made possible by these new microscopes, however, should be dramatic. With these new instruments, we should be able to examine the behavior of a single atom on the surface of a solid. This will have profound implications for the science of materials and for such practical matters as understanding how catalysis works.

In this country, most fundamental research is conducted in universities. University scientists and engineers must have access to state of the art instrumentation if they are to be effective, and this is important for industrial research as well for, two reasons:

Applied research depends on basic research results, and instrumentation developed by university scientists and engineers is often adapted later for use in industrial laboratories.

In fiscal year 1985, NSF support for advanced instrumentation will rise from $195 to $237 million. This support will be provided in three ways:

First, we will provide adequate instrumentation funds in individual project grants.

Second, we will support university centers and facilities which require instrumentation on a scale beyond that appropriate to individual project awards. These centers will be concentrated in engineering and the physical sciences.

Third, we will support major instrumentation in national centers used by scientists and engineers throughout the country. The major astronomical observatories, the new drillship, and the Cornell Electron Storage Ring are examples of this scale of instrumentation.

This emphasis on instrumentation, if maintained for at least the next several years, will significantly restore the declines which university research laboratories suffered during the 1970's.

ADVANCED SCIENTIFIC COMPUTING FACILITIES

A special case of the need for state of the art instrumentation is that of advanced scientific computing facilities. Computers are now used widely in virtually all disciplines. They have dramatically altered the way research is conducted and have fundamentally changed the problems that scientists and engineers can address.

For example, in astronomy, high energy physics, and chemistry, computers routinely monitor and control complex arrays of measuring instruments.

In many social science disciplines, computers have become indispensable for analyzing markets, demographic data and surveys. The large data bases we support cannot be used effectively without large computers.

In engineering, computers are necessary in advanced design and manufacturing and in modeling complex systems.

In the atmospheric sciences, physical sciences, econometrics, and engineering, computers are used increasingly to simulate large, complex systems.

The scale of computing involved requires the very largest and fastest machines available. We could effectively use machines many times faster than the best we have now.

Progress in several fundamental science and engineering disciplines depends heavily on the speed and memory capacity of the most advanced computational facilities.

The National Science Foundation expects to make advanced computers available to university research groups, first, by arranging blocks of time for its grantees at existing computational facilities; second, by providing networks among computational facilities, thus greatly enhancing the power of the combined facilities, and third, by supporting the development of new regional facilities to serve the computational needs of large numbers of academic researchers.

In fiscal year 1985 the Foundation proposes to spend about $20 million on these efforts. In addition, we request $5 million to start acquisition of the advanced vector computer [AVC] for the National Center for Atmospheric Research [NCAR].

The NCAR computing center is already one of the most advanced scientific computing facilities in the world. Even with this facility, however, progress in atmospheric science is limited by the computational time necessary to operate large scale atmospheric models.

The AVC will expand NCAR's capability by an order of magnitude or more which will make significant progress in this science possible.

The Foundation also supports research related to developing new computers. Research on advanced computers will total at least $10 million in fiscal year 1985, mostly through the Computer Research Division and the Division of Electrical, Computer and Systems Engineering.

SCIENCE AND ENGINEERING EDUCATION

Mr. Chairman, as you are aware, the National Science Foundation has a long history of involvement in science and engineering education. With increased funding of this area in the fiscal year 1984 budget, the Foundation staff has been actively designing a new program, drawing on past successes and perceived national needs, to address our responsibilities and effectively apply our limited funds in a fiscally responsible manner.

We have been guided in large part by the recommendations of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology. Their report identifies three kinds of talent we need in our pool of citizenry:

Professional scientists, engineers and technologists, the centerpiece of a technological society;

The investors, businessmen, legislators and decisionmakers who must have an understanding of science and technology to carry out their day-to-day work; and

An aware and understanding citizenry.

And this educational system must serve students with immensely varied abilities and cultural backgrounds.

The problem is how NSF can help provide a system that serves this full spectrum with a high quality of education.

This represents a significant change for NSF. We traditionally, and appropriately, have been concerned with the supply of mathematicians, scientists and engineers. Our graduate programs, our support of academic institutions, our development of exemplary curricula in the major disciplines, and our efforts to upgrade the skills of science teachers have all been directed toward this objective, and they have been very successful.

Our scientists continue to win Nobel Prizes, and we remain the creative scientific center of the world, but now the country challenges us with a much more difficult problem, the quality of general education for all students. We welcome that challenge. We believe that NSF can play a significant role.

At the same time, we are keenly aware of the pluralist nature of our system. There are important and appropriate limitations, both for government in general and the National Science Foundation in particular.

The Federal Government cannot and should not be the center of education. Its role must be to support, encourage and complement the efforts of State and local educators. The role of the National Science Foundation must be even more restricted.

NSF's principal strengths are its close ties with academic institutions, its experience in supporting research, and its tradition of peer review to ensure excellence. It is not our place to participate directly in the educational enterprise. Rather, our best role is as a catalyst, encouraging and supporting the participation of such diverse groups as scientific societies, educational publishers, educational developers, and school systems.

The appropriate role for NSF is to encourage these diverse agents to work together to provide effective and proven alternatives, from which local school systems may choose.

With these ideas in mind, our initial program has two major program elements:

One, an element that is concerned with the means to increase the knowledge and skills of practicing teachers and to enhance the prestige of the profession; to develop materials and teaching aids to make difficult concepts clear to all students; to demonstrate new methods that can improve the teaching environment; and to develop new technology that can improve the efficiency and effectiveness of science teaching.

Two, the second element is concerned with better understanding of science education problems; assessing the success of existing and new tools and methodologies; and pursuing approaches that offer promise of improvement in science education outside the classroom.

In support of those efforts is the Foundation's traditional role of evaluating proposals on the basis of merit and the close ties which Foundation managers have with the traditional science and engineering community.

A hybrid management style is required to carry out the tasks I have outlined. We must have a system that is open to any proposal of merit, yet at the same time can constrain its efforts to planned tracks which proceed from problems, to ideas, to major development, and finally to active application in an appreciable number of classrooms.

We are encouraging the convening of planning workshops to help develop consensus on needs and thereby focus the proposals that are submitted to us. We will then use peer review to select among the best of these proposals.

We are, at the present time, actively developing an organizational and management structure that will work effectively in this manner.

The Science and Engineering Education Directorate was re-established on October 1, 1983, and we are working to staff this directorate with experts in the appropriate fields.

We have committed nearly all 1983 appropriated funds, mostly to teaching materials development and honors teacher workshops. We are working hard now to evaluate the 1984 proposal group.

In sum, Mr. Chairman, NSF seeks a science education environment that is more stable and consistent, that serves the needs of both general and professional cadres, and where re-examination and self-correction are an integral part of the system.

In such an environment, NSF can play its proper role of catalyst and supporter.

Mr. Chairman, this concludes my prepared oral testimony.

I think we should delay the film at this time and go directly to questions.

Mr. **Walgren**. Fine.

Dr. **Knapp**. Dr. Good and I are prepared to answer questions at this time.

[The biographical sketch of Dr. Good and the prepared statement of Dr. Knapp follow:]

MARY LOWE GOOD

Vice President - Director of Research
UOP Inc.
Ten UOP Plaza
Des Plaines, IL 60016

Education

Ph.D. in Chemistry (Inorganic), University of Arkansas, Fayetteville.

Experience

Instructor and Assistant Professor of Chemistry, Louisiana State University, 1954-58; Associate Professor, Professor and Boyd Professor of Chemistry, University of New Orleans, 1958-78; Boyd Professor of Materials Science, Louisiana State University, 1979-1981. Vice President-Director of Research, UOP Inc., 1981-.

Research Activities

Spectroscopic techniques applied to materials characterization; solid state and surface chemistry; characterization of the chemical, physical and environmental properties of antifouling marine coatings containing organometallic toxicants; marine corrosion; preparation and characterization of transition metal complexes which exhibit low dimensional magnetic properties; complex chemistry of ruthenium and the characterization of supported ruthenium catalysts. Approximately 100 articles in refereed technical journals, one book.

Current Professional Activities

Member of the Chemistry Division Review Committee, Oak Ridge National Laboratory; member of Harvard Board of Overseers Committee for Chemistry Department Review; President of the Inorganic Division of the International Union of Pure and Applied Chemistry; member, Society Committee for Chemical Abstracts Comm. (ACS); member, Editorial Board of *Inorganic Chemistry*; member, National Academy of Sciences Panel on Scientific Communications and National Security; Vice Chairman, National Science Board.

Honors and Awards

Agnes Faye Morgan Research Award from Iota Sigma Pi, 1969; listed in 1971 and 1973 volumes of Outstanding Educators; Distinguished Alumni Member of Phi Beta Kappa, 1972; Garvan Medal of the American Chemical Society, 1973; Distinguished Alumni Citation, University of Arkansas, 1973; AIC Honor Scroll of the Louisiana Chapter, 1974; Teacher of the Year Award, Delta Kappa Gamma, 1974; Named Boyd Professor of Chemistry at University of New Orleans by LSU Board of Supervisors, 1974; Herty Medal of the Georgia Section of the American Chemical Society, 1975; Flordia Section Award (ACS) for Outstanding Research, Teaching and Public Service, 1979; Honorary Doctor of Laws degree, May 1979 Commencement, University of Arkansas; American Institute of Chemists Gold Medal for 1983.

Other Professional and Community Activities

Chairman, Amelia Earhart Fellowship Committee of Zonta International; Past Member of the Board of Directors of Oak Ridge Associated Universities (1971-76); Past Chairman, Board of Directors of the American Chemical Society (1978 and 1980); Past Member of National Advisory Panels - Chemistry Section, NSF (1972-76); NIH Committee on Medicinal Chemistry (1972-76); Office of Air Force Research (1974-78); Chemistry Committee, Brookhaven National Laboratory (1973-77); Science Information Task Force, NSF (1977). Member of Mayor Byrne's Task Force on High Technology Development (1981-83).

National
Science
Foundation

STATEMENT OF

DR. EDWARD A. KNAPP

DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

FEBRUARY 9, 1984

Mr. Chairman, Members of the Committee --

I am pleased to be here today for the second day of hearings on the Administration's FY 1985 budget request for the National Science Foundation.

With me today is Dr. Mary Good, Vice-Chairman of the National Science Board, who is here to respond to any questions you may have. Last Friday I described some of the important scientific questions which this budget will help us address, and I discussed two major policy issues that my colleagues on the National Science Board and I regard as deserving special attention. Today I would like to discuss research instrumentation, an issue which affects nearly every program in the Foundation. I will then return to two issues which Dr. Branscomb raised last week: supercomputers and science education.

Instrumentation for Experimental Research

Advances in science and engineering result from the interplay between experiment and hypotheses. Successful experiments stimulate new hypotheses. New hypotheses in turn require further experimentation -- or observation, in sciences like astronomy. Both experimentation and observation involve measurement, and thus advances in science and engineering come to depend on new and better instruments.

Conversely, the instruments themselves are often products of science and engineering. Many indispensable instruments today -- lasers, spectrometers, electron microscopes, and computers, for example -- were made possible by basic research in science and engineering. This process is continuous: advances in technology make possible the tools needed for advances in fundamental research, and fundamental research makes possible the technologies required for new generations of scientific instruments.

The process leads to a practical problem, however: scientific instruments become obsolete rapidly. They need to be replaced regularly, not because they are worn-out, but rather because more capable instruments simply make them ineffective. For example, the electron microscope of the 1960's cost perhaps $100,000 and could "see" an object smaller than a millionth of a meter, or something between 1,000 and 10,000 angstroms. It was the premier instrument of that time. In 1970 the scanning transmission electron microscope improved this resolution by a factor of a thousand; it could resolve objects only five angstroms across. Further improvements may allow resolution that is ten times better than that. But the cost is also higher -- the new microscope will cost at least a million dollars.

The scientific progress made possible by these new microscopes, however, should be dramatic. With these new instruments we should be able to examine the behavior of a single atom on the surface of a solid. This will have profound implications for the science of materials and for such practical matters as understanding how catalysis works.

In this country most fundamental research is conducted in universities. University scientists and engineers must have access to state-of-the-art instrumentation if they are to be effective. And this is important for industrial research as well, for two reasons:

- Applied research depends on basic research results; and
- Instrumentation developed by university scientists and engineers is often adapted later for use in industrial laboratories.

In FY 1985 NSF support for advanced instrumentation will rise from $195 to $237 million. This support will be provided in three ways:

- First, we will provide adequate instrumentation funds in individual project grants.

- Second, we will support university centers and facilities which require instrumentation on a scale beyond that appropriate to an individual project award. These centers will be concentrated in engineering and the physical sciences.

- Third, we will support major instrumentation in national centers used by scientists and engineers throughout the country. The major astronomical observatories, the new drillship, and the Cornell Electron Storage Ring are examples of this scale of instrumentation.

This emphasis on instrumentation, if maintained for at least the next several years, will significantly restore the declines which university research laboratories suffered during the 1970's.

Advanced Scientific Computing Facilities

A special case of the need for state-of-the-art instrumentation is that of advanced scientific computing facilities. Computers are now used widely in virtually all disciplines. They have dramatically altered the way research is conducted and have fundamentally changed the problems that scientists and engineers can address. For example:

- In astronomy, high energy physics, and chemistry, computers routinely monitor and control complex arrays of measuring instruments.

- In many social science disciplines, computers have become indispensible for analyzing markets, demographic data, and surveys. The large data bases we support cannot be used effectively without large computers.

- In engineering, computers are necessary in advanced design and manufacturing, and in modeling complex systems.

- In the atmospheric sciences, physical sciences, econometrics, and engineering, computers are used increasingly to simulate large, complex systems. The scale of computing involved requires the very largest and fastest machines available. We could effectively use machines many times faster than the best we have now.

Progress in several fundamental science and engineering disciplines depends heavily on the speed and memory capacity of the most advanced computational facilities. The National Science Foundation expects to make advanced computers available to university research groups:

- First, by arranging blocks of time for its grantees at existing computational facilities;

- Second, by providing networks among computational facilities, thus greatly enhancing the power of the combined facilities; and

- Third, by supporting the development of new regional facilities to serve the computational needs of large numbers of academic researchers.

In FY 1985 the Foundation proposes to spend about $20 million on these efforts. In addition, we request $5 million to start acquisition of the Advanced Vector Computer (AVC) for the National Center for Atmospheric Research (NCAR). The NCAR computing center is already one of the most advanced scientific computing facilities in the world. Even with this facility, however, progress in atmospheric science is limited by the computational time necessary to operate large scale atmospheric models. The AVC will expand NCAR's capability by an order of magnitude or more, which will make significant progress in this science possible.

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- professional scientists, engineers, and technologists -- the centerpiece of a technological society;

- the investors, businessmen, legislators, and decisionmakers who must have an understanding of science and technology to carry out their day-to-day work; and

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But now the country challenges us with a much more difficult problem: the quality of general education for all students. We welcome that challenge; we believe that NSF can play a significant role.

At the same time, we are keenly aware of the pluralist nature of our system. There are important and appropriate limitations -- both for government in general and the National Science Foundation in particular. The Federal Government cannot and should not be the center of education; its role must be to support, encourage, and complement the efforts of state and local educators. The role of the

National Science Foundation must be even more restricted. NSF's principal strengths are its close ties with academic institutions, its experience in supporting research, and its tradition of peer review to ensure excellence. It is not our place to participate directly in the educational enterprise. Rather, our best role is as a catalyst, encouraging and supporting the participation of such diverse groups as scientific societies, educational publishers, educational developers, and school systems. The appropriate role for NSF is to encourage these diverse agents to work together to provide effective and proven alternatives -- from which local school systems may choose.

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1. An element that is concerned with the means to increase the knowledge and skills of practicing teachers and to enhance the prestige of the profession; to develop materials and teaching aids to make difficult concepts clear to all students; to demonstrate new methods that can improve the teaching environment; and to develop new technology that can improve the efficiency and effectiveness of science teaching.

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In support of those efforts is the Foundation's traditional role of evaluating proposals on the basis of merit, and the close ties which Foundation managers have with the traditional science and engineering community.

A hybrid management style is required to carry out the tasks I have outlined. We must have a system that is open to any proposal of merit, yet at the same time can constrain its efforts to planned tracks which proceed from problems, to ideas, to major development, and finally to active application in an appreciable number of classrooms. We are encouraging the convening of planning workshops to help develop concensus on needs and thereby focus the proposals that are submitted to us. We will then use peer review to select among the best of these proposals. We are at the present time actively developing an organizational and management structure that will work effectively in this manner.

The Science and Engineering Education Directorate was re-established on October 1st, 1983, and we are working to staff this directorate with experts in the appropriate fields. We have committed nearly all 1983 appropriated funds, mostly to teaching materials development and honors teacher development. We are working hard now to evaluate the 1984 proposal group.

In sum, Mr. Chairman, NSF seeks a science education environment that is more stable and consistent, that serves the needs of both general and professional cadres, and where reexamination and self-correction are an integral part of the system. In such an environment NSF can play its proper role of catalyst and supporter.

Mr. Chairman, this concludes my prepared oral testimony. Last week before the Committee we previewed a short film that highlights some of the work supported by NSF and illustrates the linkage between research and education. At the suggestion of your staff we are prepared to run the film again if you wish. At the conclusion of the film, Dr. Good and I will be pleased to answer any questions you and your colleagues may have.

Mr. WALGREN. Inasmuch as Mr. Gregg was unable to be here last time we were together, let me recognize Mr. Gregg at this point.

Mr. GREGG. Thank you, Mr. Chairman.

I appreciate, Doctor, your comments and your enthusiasm and commitment to science education.

Another area that involves science education is the computer issue and I was wondering whether your CSNET group, whether that has been thinking at all in terms of interactive computer programs for teaching, developing?

Dr. KNAPP. The CSNET is a network which connects the computer science departments of universities to one another for the sharing of programs of software, if you will, of messages, of research news, and is basically designed to satisfy that group of users and is not envisioned as being a network which would be used for educational purposes in, say, the precollege area.

That is not to say that such a network couldn't be developed to be useful in the precollege, the high school and junior high school and perhaps even elementary school parts of education.

The development of good computer software and computer-aided education is an extremely complex subject. We are just getting started in our science and engineering education programs and developing materials which use computers in the classroom and are used as teaching aids. There are some classes of applications which could have transmission on network type communication links.

There are others which the cost of providing a link with enough data transmission capability would be prohibitively expensive.

We have to probably wait for a little while before we really have an opportunity to think about networking in the educational environment and evaluate what the opportunities are.

Mr. GREGG. That is certainly probably true because of the fact that we don't yet have the software network, but are you thinking about developing software for elementary/secondary school science courses, and is that a NSF role?

Dr. **Knapp**. That is an NSF role and we have a very active program.

A third of the proposals evaluated so far have that sort of an element of software development in them.

Mr. **Gregg**. Is that coming out of the money that is in the Education Directorate or out of the computer?

Dr. **Knapp**. That will be coming out of the Education Directorate funds, part of the materials development; one of the sub groups of the materials development is applying new technologies to teaching which, in this particular case, is primarily the application of the computer or video disc, display-type things, and a computer is about a third of that entire program.

Mr. **Gregg**. Those are my basic questions.

Your presentation and our discussions earlier answered most of my questions. I am enthusiastic about the direction you are taking in this area and in other areas.

Dr. **Knapp**. Thank you.

Mr. **Walgren**. Let me ask you to talk about a couple of areas, more for the record, I think, than anything else, but it is a mechanism by which we can work with you on future directions.

Can you give me just—I know it can only be general—but there are differences in the percentages of increases in the various efforts, directions. Engineering was increased by 22 percent and we applaud that and we try to encourage you to both of those areas that have in our view been left behind, but I would like to know a little bit more about how you reached those numerical numbers of increase.

How do you do that in the process of putting a budget together?

Dr. **Knapp**. As you realize, it is a very complicated and lengthy process. Our process starts with the deliberations of the National Science Board on priorities in science and the state of the various disciplines of science with respect to other sciences and the promise and the opportunities that are apparent.

That is primarily the National Science Board's role in the budget process.

A budget committee of the National Science Board working with the staff of the National Science Foundation, drafts a first budget which is presented to the OMB. Within each of the directorates, under the overall guidance of the Science Board, the distribution is suggested between the disciplines in any one directorate, like, for example, the balance in the AAEO directorate between astronomy, earth sciences, atmospheric sciences is a combination of new initiatives, new computers to buy, new telescopes to buy, the base program, how it has to be divided, and perceived problems that need to be fixed.

This budget, then, of course, is transmitted to the OMB. The OMB examiners come and visit each directorate. They try to understand the programs. We negotiate with them and, after a long and lengthy process, we come forward with the President's budget.

Mr. **Walgren**. What is the time lag between a perceived need in an astronomical area and its working its way through this process to be reflected in the numbers that you submit to the Congress?

Dr. **Knapp**. It is quite long.

In the case of the VLBA, that has been in the planning stages. We will start construction in 1985, and it has been in the planning stages for 4 years already, and the field report which evaluated the VLBA already had a proposal to evaluate, and that was 2 years ago, so it must be 5, 6, 7 years from the time a major instrument comes forward until the time it arrives in a budget for construction.

In the case of problems within a discipline, mathematics is the discipline which we are trying to support this year, very heavily, because of perceived problems within its inner structure. The problems that mathematics has stem from the late 1960's, early 1970's, so it has been 12, 14 years since they started having some funding difficulties for that first to be perceived by the community and to be brought to the attention of the management of the Foundation and worked into budgets to try to rectify that problem.

That seems like a terribly long time, but it really is that long.

In the case of engineering, as you well know, the Foundation has been grappling with how to handle engineering within the Foundation and give it a status and a support which we feel the Foundation should accord to engineering, and that program is several years—the new initiative which we are having for the 1985 year which we described Friday, was discussed for several years, discussed in detail this summer by the National Science Board, and we had a number of discussions with the Academy of Engineering. It was in the budget much more quickly after we got an idea which direction we should go and after there was a consensus in the community.

Mr. **Walgren**. You mentioned in your statement reversing the decline of the instrumentation facilities suffered in the 1970s.

Dr. **Knapp**. A combination of a number of things. The purchasing power of science budgets stayed roughly constant from 1970 to 1980. Up a little here, down a little there, but more or less uniform.

At the same time, instrumentation was becoming more expensive, as I explained in my testimony, and at the same time, as we were expanding the number of researchers that we had in universities, and one thing gave in that whole system.

We stopped giving the full amount of funds to research grants. We would cut back on the number, the dollar level support we would provide, and researcher decided that the thing that he could put off until next year was the purchase of an instrument. That went for 10 years, and we are now reversing that as rapidly as we can.

Mr. **Walgren**. You mentioned the very long, large base line array and on a tangential direction I wanted to ask, this is a big program?

Dr. **Knapp**. Yes.

Mr. **Walgren**. Are they equipped to fund it?

Dr. **Knapp**. The NSF has funded a number of large construction projects in the past, and some have been successful in the past.

Our style is quite different in the way we manage large construction projects.

There is a term my ex-boss, Harold Agnew, invented; he called it "micromanagement."

He talked about the way another agency was managing his laboratory.

We try very hard to insist that the university which is in charge of the construction project have a very tight management plan and that they adhere to it and meet the schedules.

We don't monitor, at all times, the exact position of this construction project. That is the responsibility of the university as a contractor or a grantee to us.

Mr. WALGREN. You say you don't monitor its progress at all times?

Dr. KNAPP. We don't monitor specific lines in it. We monitor, at all times, the progress with respect to their goals, but, for example, we do not have a representative of the government on site. In that sense, we do not manage.

Some notable examples of success are the CESR accelerator at Cornell, the most cost effective accelerator for physics ever built, at least in the couple of decades, and the Cyclotron in Indiana. These are exemplary projects which were managed on budget, on time lines that were established, and I think——

Mr. WALGREN. And then are there other examples on the other side?

Dr. KNAPP. There was an accelerator which was at the NEVIS Laboratories of Columbia University which was never completed because of technical problems they got into, but it was terminated before a great deal of money was spent on it.

Mr. WALGREN. Have we as management tried to look at the difference between the success and the failures and ask what made the difference?

Dr. KNAPP. Absolutely, we have, and we have a very good internal system now to identify problems early in the system and to rectify them.

Mr. WALGREN. Maybe I can ask you to elaborate on that internal system, perhaps in a submission, if you are not in a position to shed any more light on it right now.

Dr. KNAPP. I am not, and I will do that.

Mr. WALGREN. I realize that, for sake of accuracy, we would like to be able to understand the efforts made by the National Science Foundation management to make sure that the right things are happening in that particular area. Apparently there is a cyclotron radiation facility under construction at the University of Wisconsin that is having some difficulties. Could you perhaps, in a submission, elaborate on whatever, if any, problems there are there and perhaps use that as a way of telling us how you are managing these?

Dr. KNAPP. That is an excellent example to use of the method that NSF uses to manage these large projects.

Dr. Marcel Bardon is in charge of the Mathematical and Physical Sciences Directorate of the Foundation. He could say a word or two if you wished, at this time, on the particular problem, or we could make a submission.

Dr. BARDON. As you point out, there indeed have been considerable concerns about the facility at the University of Wisconsin, and we have tried to deal with that problem as early as possible. The way we deal with that is by assembling a group of experts from outside the NSF and outside the Government who are experts in the kind of problems that we think the institution faces.

In this case, it has to do with the way in which the design is progressing and whether or not the most advanced methods of analyzing and engineering the problems are really being carried out and also whether the distribution of the laboratory is appropriate for this kind of concern.

Our conclusion of the review was indeed that the direction of the laboratory was not appropriate, and the methods used were not appropriate, and some vigorous steps were taken. There has been a new director already appointed to the laboratory. One had to be located. He had to accept and be appointed, and all of that was done between October and November.

The chancellor of the university has decided, himself, to become a coprincipal investigator on the project and put the overall resources of a very large university directly on line to help the project.

He is, himself, a chemist who uses that facility, so it is very appropriate that he should keep very close track.

The reporting structure within the university was a problem; that is, the sequence of people to whom the director had to report in order to get something done. All of that has now been bypassed. The director of the laboratory reports directly to the chancellor of the university so we find that, with the new methods and the new director who is an expert in the field, we expect considerable progress.

Mr. WALGREN. Perhaps in your submission you might relate that experience with these internal steps that you indicate you have taken to be sure that management stays very much in, or very aware.

Dr. KNAPP. These are not steps I have taken but steps which have been at the Foundation and are continuing.

[The information follows:]

MANAGING LARGE CONSTRUCTION PROJECTS

THE UNIVERSITY OF WISCONSIN SYNCHROTRON RADIATION FACILITY

The Division of Materials Research follows normal NSF procedures in initiating construction of major new research facilities and monitoring their progress. Major projects are subjected to in-depth scientific and technical review of a proposal by mail reviewers and site visitors. Major initiatives are reviewed by the Divisional Advisory Committees which advise the Divisions on research priorities. Recommendations for major projects are reviewed and approved by the National Science Board. Monitoring of construction projects is provided by periodic reports and on-site visits by NSF staff. External consultants are called in, as required.

The initiation of construction for the Aladdin synchrotron source at the Synchrotron Raidation Center (SRC) of the University of Wisconsin-Madison passed all of these review stages. The Center had been remarkably successful as a center for research in the vacuum ultraviolet region of the electromagnetic spectrum using Tantalus, a synchrotron radiation source developed at Wisconsin. They were considered to be well qualified to develop and operate a much needed second generation source.

Actual construction of Aladdin was initiated in 1979, and the basic components of the accelerator and storage ring were completed and assembled in 1981. The construction costs were $4.4M, which included $900K provided by the University of Wisconsin for a new building. Efforts to make Aladdin operational since 1981 have encountered a number of technical problems. Such problems are not unusual for new accelerators and normally can be handled without undue delay. However, following a site visit by NSF staff in the fall of 1983, it was determined that deeper problems might underlie the delays. NSF convened a committee of nationally recognized accelerator experts in the spring of 1983 to review all aspects of the Aladdin project. This committee judged Aladdin to be technically sound but identified a number of deficiencies in staffing, management and organizational structure which were hampering its development. Their conclusions and recommendations for up-grading the management and staffing of the SRC were reinforced by a scientific site visit committee which met at Wisconsin in June 1983 to review the scientific program of the SRC in the national context for synchrotron radiation research. Subsequently, the University of Wisconsin-Madison and the NSF took a number of steps to strengthen the staffing and support structure for the SRC. These steps culminated with the appointment, in December 1983, of a new Director for the Center who reports directly to the Chancellor. The NSF worked together with the University administration, during this transition period, to assure that effective management and organizational changes would be put into effect to utilize the increased level-of-support considered necessary to make Aladdin operational for synchrotron radiation research. Progress is being monitored by monthly progress reports. Additionally, NSF has called on a number of nationally recognized accelerator experts to assist the NSF staff in monitoring the Aladdin project. These experts participated in three site visits during the preceding year and will participate in four during the current year. It is recognized that the Aladdin project is at a critical stage of development. Close monitoring by NSF staff and external experts is considered essential for its successful development.

Mr. WALGREN. Mr. Boehlert?

Mr. BOEHLERT. Dr. Knapp, I am asking you this and hoping that you will be able to tell me I am all wet.

I understand recently Dr. George Michael conducted some benchmark studies comparing U.S. computers with Japanese-made computers and the other guys came out on top in those comparisons. Is that so?

Dr. KNAPP. That is what I understand.

Mr. BOEHLERT. What response do you have to that?

Dr. KNAPP. The question, what does the National—how does the National Science Foundation respond to that? We are not quite the right people to ask, but I will say what I think the country is doing and where we stand in this whole situation.

There is a competition, I think that is clear, between the United States and Japan on providing very large scale computers.

At the Livermore Laboratory, they ran some benchmark tests on the prototype Japanese computers and some production American computers, and the Japanese computers made the calculations considerably faster than the production facility computers that they had at Livermore.

That is not quite a fair comparison, because the prototype computers are not on the market yet. They can't be purchased yet.

We have some that are coming, so the comparison is not perhaps quite as bleak as you might think from reading some reports of it.

On the other hand, it is real.

Mr. BOEHLERT. Doctor, let me tell you what gives me heart palpitations.

We have NCAR and NSF buying Japanese computers instead of American computers?

Dr. KNAPP. I don't know that you would allow us to do that. The situation with what the NSF is doing in the design of large scale computers is that we have approximately $10 million of our engineering and computer science funds directed toward developing faster hardware for the inclusion in computers in university research; also in computer science research, the kinds of software that have the kinds of programs you need to operate on large scale computers. And the most important aspect of what the NSF is doing; we are trying very hard to produce people trained in all of the sciences, computer sciences, to use and design computers and our most important contribution to industry is the people that come out of the universities and go to work for the computer manufacturers and help them learn how computers are built and how to design them better.

We are a relatively small player in the overall supercomputer business. The big players are the Department of Defense and the Department of Energy. The Department of Energy, I think, owns by far the most large supercomputers in the country.

Livermore and Los Alamos probably have 20 of these machines between them, in two laboratories.

They are becoming much more important in engineering and in science. Over the next 10 years, we will see an explosion of what we can do in science because of the ability to use the very large computational facilities of this kind.

Mr. BOEHLERT. Relative to where we have been in the past?

Dr. **Knapp**. Relative to where we have been. Already, we see the aerodynamics of airplane design going from wind tunnels to computation and see the hydrodynamics of exploding systems being taken care of in computers, not experimentally, and we can expect, in many, many other fields. We think it is extremely important that the university academic scientists have access to large scale computing facilities.

We want to make that access available, not to help us build the next generation of computers.

Industry and other agencies are really more involved in that.

We feel our real main role is to make it possible for university scientists to have access to and train people on large scale computational facilities, and we have a program starting at $20 million in 1985 in our budget which will allow for both the installation of large scale computer facilities on campuses and the networking of those facilities together to many, many campuses around.

Mr. **Boehlert**. I have a recurring nightmare and it goes something like this:

It compares where we are today with computer technology with where we were 10 years ago with our U.S. auto industry, and clearly we were No. 1. We were so supremely confident that we were going to remain No. 1 forever, only we got our socks knocked off by the Japanese because they were much more aggressive, not just in the private sector, but in the public sector, from the Government.

Suddenly we woke up and discovered that we were No. 2 and I don't want that to happen in computer technology and I am concerned, and this is a story I have used before.

I am concerned, for example, when I have a friend and constituent of mine, Kenneth Wilson, at Cornell University, Nobel Prize winner, 47 years old. He doesn't have access to the latest in computer technology as much as the average graduate student in Japan or West Germany or United Kingdom.

That bothers me. So, when you talk in terms of $20 million, that is big money, but still it looks like small change when we are talking about the future direction in which we need to proceed and I think an accelerated pace.

Are we meeting the challenge or operating in splendid isolation, confident that we will remain No. 1?

Dr. **Knapp**. The way for us to remain No. 1 in large scale computing, in my opinion, and this is perhaps my agency's opinion, but my personal opinion in this case is to make sure that the market for large scale computing facilities is such that our major industry, IBM, other major computer manufacturers, feel that there is a profitable market for them to enter. I think, in fact, that—I wish very much that, this afternoon, the Chairman of the Science Board, Lewis Branscomb, was here. He is the chief scientist of IBM and could address that problem very eloquently.

I, unfortunately, cannot. I am not an expert.

I believe that if the market is there, if it is felt that this is really the direction that computing for the eighties and nineties is going, and I think it is, and industry realizes that, that a combination of Government need for these facilities, the understanding of industry need for these facilities, and an active response of our industry will keep us No. 1.

Now, how we do that in our system is not completely simple.

Mr. **Boehlert**. How can the market be there if, at our university research centers, we don't have the latest in computer technology and we don't have young graduate students exposed to the latest computer technology?

Dr. **Knapp**. That is correct, and that is the synthesis of our program.

That is the source of our concern and our putting forward a program which starts relatively slowly, but we would expect to be a major investment this country will have to make over the next 5 or more years.

Mr. **Boehlert**. I agree. I wish you would say it about 25 times to everyone that will listen.

Thank you very much.

Mr. **Walgren**. Thank you.

Mr. Dymally?

Mr. **Dymally**. Thank you, Mr. Chairman.

Dr. Knapp, last year we discussed a very interesting phenomenon in California, that is the rise of ethnic groups in our urban universities, making them minority institutions in terms of population.

With the chairman's support, and the committee's support, we brought the president of California State University to discuss this phenomenon in California.

NASA has since agreed to amend their research program for minority schools to include California institutions. An Executive order on the research initiation and minority institutions program, which HHS has complied with, but not NSF.

NSF has not included the California phenomenon in its minority program and here we have one Executive order where one branch of the Government complies but the other one does not, and to correct that we put language in the authorization bill last year and still we have not seen any results of that from NSF, so my question to you, Do we have to reinvent the wheel in the authorization bill this year again and put in the same language, or can we expect that you will help us more struggling state?

Dr. **Knapp**. I am not an expert in this particular problem at all, and I have only recently had it explained to me. I would like to ask Mr. Richard Green, assistant director that handles the program you are discussing, to briefly discuss this with you.

Mr. **Green**. Mr. Dymally, we have been operating under the Executive Order 12320, which we understood was directed at primarily and historically black colleges and universities, and have included, with the White House and OMB approval, Hispanics, Puerto Ricans, and Mexican-Americans.

I, personally, am not aware of the language which you are referring to, sir, and will check that out as to how it does apply to our programs.

Mr. **Dymally**. HHS is responding to the same Executive order by including the California phenomenon in their program, and last year we had major hearings, packed room. The president from a major university came here, discussed the phenomenon.

It is in the transcript. I don't see how NSF could miss such an important hearing that related to their budget. Somebody in the Budget Office there is missing the ball.

Mr. GREEN. I will certainly have to look at that, sir, and reply for the record.

Mr. DYMALLY. I don't want you to look at it. I really want you to implement the mandate of the committee.

The committee has said to do it.

HHS is doing it under this same executive order, and I am not interested in reports. I like to see things get done. Why write me a letter? Just implement the program.

I just hope that we do not have to bring the president of California State here. This time, I will bring the chancellor, if he is not convincing. She, too, is a scientist. He is a scientist. She is a scientist and, if necessary, we will have them come back and have the same testimony again.

Dr. KNAPP. I will have this looked into thoroughly, and we will implement the law.

Mr. DYMALLY. Thank you, sir.

Because you have been so forthright in your response, I am not going to ask other questions.

In fact, Mr. Chairman, I had other questions for Dr. Knapp, but this week I had occasion to communicate with him on an affirmative action problem and he was so prompt in his response that I would like to submit these questions to him so he can do what he did for me today by arranging to have a conference with his EEOC officer, so I will submit the rest of my questions for Dr. Knapp, to arrange a meeting for us to discuss it with his equal employment opportunity officer.

Thank you very much.

[The questions and answers follow:]

Question: What actions do you plan to take to see that NSF institutes an affirmative action policy which will restore morale and confidence in fair treatment among your Black, Hispanic, and female employees?

Answer: We are currently in a Multi-Year Affirmative Action Program Plan cycle for fiscal years 1982-1986. This plan has been submitted and reviewed by the appropriate enforcement agencies and found acceptable.

Question: What percentage of your senior level management is Black, what percentage Hispanic, and what percentage female?

Answer: NSF had 99 SES members as of February 1, 1984. Of this total, 1% were Black, 1% Hispanic, and 7% female.

Question: How many of the new hires of senior level employees at NSF in 1983 were Black, Hispanic or female, and what percentage of total senior level hires do these numbers represent?

Answer: The following information is for both 1982 and 1983.

Year	Total SES Hires	No. Black	No. Hispanic	No. Female
1982	14	0	0	3 (21%)
1983	7	0	1 (14%)	0

Question: How many EEO complaints were filed with your EEO office last year? How many of these complaints were settled?

Answer: One complaint, which was filed April 20, 1983. The employee has left the Foundation and withdrawn the complaint.

Question: Is the Affirmative Action history of a section or department head entered into his or her personnel records, and is the history taken into account in promotion considerations?

Answer: Most, if not all, section or department heads are in the SES category. NSF SES performance appraisal plans include a required element concerning promotion of equal opportunity. Performance under this element is appraised annually along with other elements, and annual performance appraisals form the basis for justification of SES pay rate increases. In addition, all applicants for SES positions must provide a narrative statement addressing, among other factors, their involvement in affirmative action and EEO.

Question: Are more EEO complaints being filed from some sections than others? It has been reported that International Affairs has been the source of an unusual number of complaints.

Answer: No.
We have received only one complaint regarding Civil Rights violation from an employee of International Affairs since the beginning of the EEO Program.

Question: To your knowledge, has any disciplinary action ever been taken against a senior administrator at NSF for an affirmative action violation?

Answer: Our personnel records do not contain any documentation of a disciplinary action for an affirmative action violation. In EEO investigations which have surfaced potential or real discriminatory issues, management has settled these cases in an informal process before the case continued to a higher level. This was done with the involvement and concurrence of the charging party.

Question: When was your last affirmative action report published? When do you expect the next one to be available?

Answer: As indicated earlier, we are presently operating within a multi-year Affirmative Action Plan for fiscal years 1982-1986. At the request of EEOC, we are updating our statistics, and the results will be published within the next two months.

Question:

The numerous studies and reports on math and science education which have recently come out all point out that women, minorities and handicapped students are underrepresented in secondary school math and science courses. What steps are being undertaken, in the programs which are in place in the education directorate at the NSF, to ensure that ALL students will benefit from improved math and science education?

Answer:

In our instructions for proposal preparation, NSF specifically invites projects aimed at "...the special needs of particular groups of students; for example women, minorities, physically disabled students, college-bound students, those entering the workforce after high school graduation, or the gifted and talented...." We are monitoring our support for projects involving these populations.

Question:

Are there targeted monies for women, minorities and handicapped in science education at the NSF?

Answer:

The Science and Engineering Education activity at NSF addresses the need to increase opportunities for women, minorities and the handicapped in science and engineering in four ways. First, a formal program of fellowships is targeted for minorities, the Minority Graduate Fellowship Program, open to applicants of ethnic groups underrepresented in advanced levels of science and engineering. Second, guidelines for all grant programs explicitly encourage participation by women, minorities and the physically disabled. Third, as mentioned above, one of the highlighted areas in which improved instructional materials projects are encouraged is the development of materials tailored to the special needs of groups such as women, minorities and the physically disabled. Fourth, one of the criteria on which all proposals are evaluated is the extent to which the proposed project reflects awareness of the needs and potential of diverse groups such as women, minorities and the physically handicapped.

Question:

I am particularly concerned by stories I've been hearing about girls and minority students not having as much access to computers as white male students, both in school and outside of school. This is both a local issue and a national problem. We should deal with it aggressively now, rather than wait for it to become an insoluble problem. What programs are currently in place at the NSF or elsewhere that address this problem?

Answer:

The stories referred to may have emanated from an NSF science education supported project carried out at the University of Minnesota which produced the report, "Computer Inequities in Opportunities for Computer Literacy." The report has been widely disseminated and suggests that racial differences in school computer use are no longer large, though gender differences still are, with males using computers much more heavily than females. Support of such studies, calling attention to national problems in science education, is a principal NSF science education activity. By producing the data needed for informed decisions, this type of support indirectly addresses the problem. In addition, the guidelines invite proposals for computer projects that address the special needs of women and other students who need to develop better computing skills.

Question:

With regard to research in minority institutions, have the eligibility guidelines for the RIMI program changed to account for the California institutions, as discussed in the FY 84 Authorization Hearings? If so, what are the eligibility requirements? Please explain the difference between the HHS program guidelines for eligibility and the NSF guidelines.

Answer:

In response to the FY 1984 Report of the House Committee on Science and Technology, the eligibility requirements for the RIMI program have been carefully reviewed to make certain that RIMI provides support for institutions that are committed to serve the needs of a substantial number of minority students. To accomplish this, the following has been added to the current statement of eligibility:

> Institutions may also qualify for support under the RIMI program by demonstrating their historical commitment to educating minority students in terms of significant enrollments, usually a minimum of 20 percent, of any one eligible ethnic minority group.

This statement generally conforms to the eligibility requirements governing NIH programs addressed to minority needs, as they are implemented in actual practice. Enrollment data are being examined to determine which additional institutions will now become eligible. At least two institutions in the California State University System will be included--CSU at Los Angeles and CSU at Dominguez Hills.

Question:

Are there staff training programs in place to aid NSF personnel in making all their funding decisions in a manner which promotes equitable treatment for women, minority and handicapped students and scientists?

Answer:

NSF provides instruction to aid NSF staff in making funding decisions in a manner which promotes equitable treatment for women, minority and handicapped students and scientists in the following ways: (1) The NSF Program Managers' Seminar, which is a week-long seminar provided twice a year for approximately 55 new NSF scientists, engineers and other professional employees, provides guidance on these issues. In addition to presentations made by Division of Research Initiation and Improvement (DRII) staff, these issues are also addressed by other guest speakers such as National Science Board members, the NSF Director, and the NSF Staff Director, as well as through classroom discussions of case studies and NSF policies; (2) during the past year, DRII staff have held briefings with all research directorates' staffs to provide instruction on these funding opportunities and issues; (3) outreach activities are provided to potential grant-recipients by various NSF staff; and (4) issuances, program materials and announcements are provided to all Foundation staff regarding mainstream as well as special funding opportunities for these target groups. Individual assistance is also provided to Program Managers regarding these funding decisions.

No other staff training activities are sponsored by NSF which specifically address these issues; however, training funds are available to NSF organizations for their use in sending employees to training outside the Foundation. Recent activities attended by NSF staff pertaining to these issues include participation in courses which covered procedures and policies relating to contracting with small business contractors, including 8(a) firms, such as "Contracting with Small and Disadvantaged Businesses."

Question: Despite the widely acknowledged need for improvement in math/science and engineering education, especially at the elementary and secondary levels of education, the proposed level of funding for FY 85 for the science education directorate of the NSF is only 0.9% more than the FY 84 level. All of this meager increase is for graduate fellowships. Programs directed towards elementary and secondary math/science education are level funded. Why has this demonstrated national need for improved math/science education been ignored?

Answer: The Foundation began to rebuild its precollege science and mathematics education programs in FY 1983 with a $15 million appropriation. In FY 1984, the precollege program received a $54.7 million appropriation--an increase of approximately 260 percent over the FY 1983 appropriation. The Foundation has requested level funding in FY 1985 because we are in the process of starting new activities, including developing program plans and acquiring the highest quality staff, and of expending the FY 1983 funds carried over into FY 1984. Because of the start-up activities, it is doubtful that we can wisely spend funds above our FY 1985 request. In fact, it will be difficult to fully obligate all FY 1984 funds by the end of the fiscal year. We believe that careful planning, together with our requested level of support for SEE, will enable the Foundation to assist in meeting the challenges facing the nation today in science and mathematics education.

Question: Are there women, members of minority groups, and handicapped scientists on staff and involved in funding decisions in the education directorate?

Answer: The SEE Directorate is authorized 50 FTE (plus 1 Intergovernmental Personnel Act slot) in FY 1984. Currently 39 of those 50 FTE slots are filled.

Twenty-five of the thirty-nine FTE's are women, six of whom are involved in funding decisions, including the Acting Assistant Director, a division head, two program persons and two policy staff. Seven of the thirty-nine represent minority groups, but none of them are involved in funding decisions. No handicapped persons are currently employed.

Question: Is an advisory committee or some other mechanism being set up to provide outside advice to the NSF education directorate? If so, will this committee include experts in the area of intervention programs which increase the participation of women, minorities, and handicapped students? If not, why not?

Answer: The NSF recently received approval from the General Services Administration to re-charter an Advisory Committee on Science and Engineering Education (ACSEE). As provided in the Charter, ACSEE will consist of up to 20 members who are experts in the fields of science and engineering education. The Foundation has received to date the names of close to 200 nominees. The Charter provides: "Members of the Committee shall be chosen from among experts in the fields of science and engineering education in a manner so as to provide appropriate balance among: various scientific and engineering disciplines, and institutional types, including educational institutions at all levels, industry, and nonprofit organizations as appropriate.

Furthermore, those chosen shall reflect a balance derived from the consideration of other important indices, including the geographic location and sex of its members, and the participation of groups underrepresented in science and engineering." The Charter further provides that final selections will be made by the Assistant Director, SEE.

Mr. Walgren. Thank you, Mr. Dymally.

Mr. Skeen?

Mr. Skeen. Thank you, Mr. Chairman.

Along with the same question that Mr. Dymally had asked: Dr. Knapp, I understand that NSF has several minority programs under way and I commend the Foundation for that, but I have one or two questions.

Has any thought been given to the process of some kind of incentive to help those that are on so-called minority program awards to render themselves independent of that and move into the mainstream as sort of a transitional-type thing?

I am concerned about any kind of program that becomes a stationary or permanent type thing to help minority groups and so forth, which I am very much in favor of doing, but I want to see them move into the mainstream of scientific activity and development and program.

Has NSF been concerned with that phase?

Dr. Knapp. Yes, we are very concerned with that and, in fact, last year at these hearings I described a management plan that I had to try to better integrate the minority programs into the mainstream programs of the Foundation.

The plan that I described last year has been implemented in modified form.

The minority, women, and handicapped programs remain in the Foundation as set-asides in the organization, but I have asked the research directorates to develop for me plans which will allow this movement of people in these special programs into the mainstream of the scientific activity by paying special attention to the problems that special groups have and trying to overcome these problems in their dealing with the—by their awareness of the problem, and their dealing with the way that the grants are awarded.

The judgment, the peer review, and the awarding of grants is not just a mechanical process. It has a lot of judgment and a number of places in it, and we want that judgment to be exercised where we can help people who have been in one category of grant get into the main scientific stream of American university work.

Mr. Skeen. Thank you, Doctor. There is also an assertion or an impression among some of the people in the scientific community that it is hard to break into the NSF system unless you are one of the good old boys or something of that nature, and I would appreciate some response to that.

Is there any real basis for that concern?

Dr. Knapp. There is an impression that that is perhaps the case. We have done a number of studies that indicate there is not a strong bias toward the good old boys, so to speak.

Mr. Skeen. That is all of us, Doctor.

Dr. Knapp. We are all the good old boys, right.

We have, of course, this year, a program, the Presidential young investigators program, just starting, awards to be made this month, which bring 200 young investigators in the first few years after they have received their Ph.D., into the system. It is a very innovative program and we are very excited about it.

Mr. Dymally. Let the record show Mr. Skeen and Mr. Knapp are from New Mexico.

Mr. **Skeen**. We would advise you under any kind of circumstances, immigration or otherwise, to become a native. We would be happy to have you as a citizen.

One question on this, to change the subject to the very long baseline array that you announce. This will be done in cooperation with university laboratories and how will they be selected?

Dr. **Knapp**. The observation time will be on the basis of scientific proposals to the facility from any astronomer with any university, who proposes a particular observation that he would like to have made, being eligible for judgment and peer review. The time on that instrument will be allocated to the observations which are felt to be the most scientifically promising.

Mr. **Skeen**. Thank you, Dr. Knapp.

Thank you.

Mr. **Walgren**. Let me just ask, if I might, you mentioned a study that shows that good old boys do not prevail and perhaps you could submit a summary of that study.

Dr. **Knapp**. This was a study done by our Office of Audit and Oversight, and I think it was a year or so ago that the results of that study were made available.

Mr. **Walgren**. We would appreciate if you would have somebody submit a summary of it in pertinent part.

[The requested information follows:]

Summary of Studies of Fairness in the NSF Award Decision Process

Every year for the past three years the NSF has done a study of the fairness of the NSF award decision process. The most recent study found that there was no preference for or against women or young investigators, i.e., for roughly the same proposal quantity both women and young investigators have the same chance of getting an award as men or older established investigators. A very slight preference was found for higher quality (as determined by an NAS study) departments on new proposals, but not for renewal proposals.

The previous study concentrated on the geographic location of the proposing institution. The quality rating of the proposal was the overwhelming dominant factor in the decision. Again, a slight preference for institutions of highest quality was found. No preference for one state versus another was seen.

Dr. **Knapp**. I also believe there was a study reported in Science magazine about 1 year ago on this perceived problem with the same general result.

Mr. **Walgren**. OK. Now then, you also mentioned that, in response to Mr. Skeen, as I understand it, that the attempt is to get some of the, you call them affirmative action type efforts, mainstreamed into the directorates. Is that an unfair statement?

Dr. **Knapp**. We are not, at the present time, talking of mainstreaming the congressionally mandated set-aside programs for affirmative action.

Mr. **Walgren**. Mr. Skeen said, gee, these things have to go on forever, and you said, no, they don't have to and in fact we tried to merge them.

Dr. **Knapp**. What I meant to say was, however the language came out, what I meant to say was that we did not expect minority scientists, a particular scientist, to stay in those programs forever.

We would like the program to make it possible for a minority, woman scientist, a handicapped scientist, having participated in that program, to then compete successfully in the main line programs of the Foundation and that new minority scientists, young people, would then come in and participate and also be made so that they can participate in the mainline programs.

In other words, that we not have a group of people who always get, for many years, their support from a program which is set aside.

Mr. **Walgren**. Yes, and that brings me to the area that I wanted to ask you to address. You are trying to build a management tracking system at NSF, as I understand it, and you had hoped that this tracking system would be able to give you a great deal of information about what was going on, particularly with some of the STIA type programs that you were trying to pick up in the overall thrust of things, the goals of those programs you were trying to pick up.

The question is, how is that management system running? Is it in place, and is it sensitive enough to tell us whether or not these minority scientists are successfully competing for these other grants?

I better go respond to a vote. We will pick up at that point in 10 minutes when I get back.

[Recess.]

Mr. **Walgren**. We ended with a question and wanted to give you an opportunity to talk about the management system and its sensitivity in tracking some of these elements that we want to be sure are taken into account.

Dr. **Knapp**. I should make a few comments about our Management Information System.

We are in the process of building a new management information system for the Foundation, based on a new computer which will come online fulltime this fall.

Within that management system, we expect to have work stations located quite heavily around the Foundation in all of the directorates.

We are just developing it.

One of the major goals of the MIS, or the Management Information System, is to be able to track things like participation of women, minorities, the handicapped in programs of the Foundation, be able to track the kinds of grants, lots and lots of different information.

At the present time, the program is nowhere near as well implemented as we would like because we have had a rather severe shortage of PD&M funds from which the program is taken.

We have taken steps this year to make sure we no longer delay the implementation of the system and get it in place as quickly as possible. We are writing software for the system which will allow us to track different kinds of information, some useful for management of the Foundation, and other useful for the program officers who have to manipulate, handle and put out grants.

It is a very versatile system, and when it is online we will be able to answer the very large-scale management questions you have just been talking about and help the efficiency of our entire operation by really a major leap forward in that.

Mr. **Walgren**. Will it track overhead costs versus direct costs?

Dr. **Knapp**. Oh, yes; I am certain that it will.

Mr. **Walgren.** One other question on management information. It is said that the National Science Foundation is one of the few agencies that does not submit summaries of ongoing research to the National Technical Information Service. Is that true, and is there a reason for that?

Dr. **Knapp.** I am sorry. I do not know the answer to that.

Perhaps Mr. Ubois, the Assistant Director for Administration, who is here to answer that question—he was here.

Dr. Hayes, the Controller of the Foundation, could perhaps answer that question.

Dr. **Hayes.** My understanding of the situation is that there have been discussions about the extent to which this information would be used and the cost of producing this information in the form it was requested, and after these discussions, it was concluded that the return was not commensurate with the costs to the Foundation in the way it was proposed.

Mr. **Walgren.** Who would make that decision that the return is not equal to the cost?

Dr. **Hayes.** That is a matter that, I think, has two components. It is one that is a judgment of the Foundation who participated in this discussion, based on the assessment of what it would cost in terms of staff time relative to tradeoffs that would have to be made within what is a very tight PD&M budget to carry out these kinds of functions.

Mr. **Walgren.** Who would make that decision? Obviously the Director did not make that decision.

Dr. **Hayes.** I believe that the decision traces back approximately a year or more, before the time that I was controller.

Possibly Thomas Ubois, who just came in, can answer that.

Mr. **Walgren.** The question was the Science Foundation is one of the few agencies that does not participate in the National Technical Information Service summaries, or provide summaries of ongoing research to the National Technical Information Service. The question is why is that the case, and have we thought through that position?

If there is anything briefly you would like to respond to. Perhaps it is something that should be thought through with the Director and give us a response and a formal position.

Mr. **Ubois.** Thomas Ubois, Assistant Director for Administration.

We had been, prior to the transfer of SSIE to NTIS, providing SSIE all of the information on research awards being made by the Foundation.

When that responsibility was transferred to NTIS, we were involved in discussions with them about providing similar kinds of information in different ways to them and just determined that it really wasn't very cost effective for us to comply fully with the NTIS request for that information

I would be glad to elaborate on that and detail the reasons for our position for the record.

Mr. **Walgren.** That would be fine.

[The requested information follows:]

National Technical Information Service

NSF provided the initial funds to establish the Science Information Exchange (predecessor to the Smithsonian Science Information Exchange, in turn transferred to NTIS in 1981) and was the sole source of support for many years. Input from Federal agencies was in the form of abstracts of ongoing research, at NSF known as Form 4, sent to SIE/SSIE at the time an award was made. Profesional staff at SIE/SSIE did the indexing and arranging of the information to enable retrieval.

When the service was transferred to NTIS in 1981, that element of the Department of Commerce required to make the service self-supporting was no longer able to accept Form 4, but required instead from agencies computer tapes containing abstracts as well as indices in accordance with a multivolume thesaurus maintained by SSIE.

On December 9, 1981, in a meeting of the Foundation's MIS Steering Committee (chaired at that time by the Deputy Director) with representatives of NTIS and OSTP, the decision was made that NSF was unable to comply with the request, as it did not have the resources (roughly estimated at $250,000, including three full-time employees), nor was it clear that much use was made of the service by the academic community, NSF's principal client. (Form 4 has since been discontinued.) Few NSF Program Directors have used the service, and even fewer have found it comprehensive enough to be useful.

On October 6, 1983, the Director of OAO and DAD/A met with GAO representatives to explain why NSF was not able to provide the computer tapes to NTIS. It was stressed to the GAO representatives that not only was the cost high and the utility to NSF and the academic community questionable, but that the indexing part would be a very heavy workload imposition on every Program Director at NSF, a commitment NSF was not able and willing to make.

Mr. Walgren. Let me ask some structural thoughts as the previous questions tended to be management details. But thinking structurally of the NSF and the thought that the institutional base of allocating a grant makes it difficult to accomplish some objectives in the computer, particularly the supercomputer area. Let me ask whether or not this supercomputer program or efforts that NSF should make somehow do have to rise above what is apparently described as the entrepreneurial, institutionally-based approach for academic computing. I wanted to ask Dr. Good, does the Science Board get involved in looking at and coming to some judgment about whether the pure structure of the organization and its traditions is adequate to respond to things like the supercomputer need?

Dr. Good. Yes, Mr. Chairman, the National Science Board, over the last 2 or 3 years, has spent really quite a lot of time discussing that issue. It has to do primarily with just the kinds of things you described. The ongoing programs, and, if you like, the basic program of the Foundation functions very well on the peer review system, unsolicited grants, proposals and so on.

We have looked at it in the supercomputer field and the other initiatives that you see, and biotechnology is one of those.

The plant biology initiative is another.

Mr. Walgren. Please tell us the Board's views in those areas.

Dr. Good. In the Board's reviews, we had Dr. Knapp and his staff actually review the programs within the Foundation which were pertinent to the basic biology issues, for example, and basic engineering issues, because biotechnology actually is in both areas, in engineering and in the basic biological sciences.

We had also a number of what we considered to be experts in those fields, in other words, people who were at the cutting edge of the technology or the science, come to the Board, particularly in the biotechnology area, and discuss those issues with us.

There was a lot of information provided by the staff, and the decision was made (and these are always subjective decisions, as you can understand), but the decision was made that those were two areas which would probably not surface quickly enough if left just to grants that came in from the field without an announcement of a program.

For that reason, they were put in as initiatives, so that we will get those proposals and they will understand that the Foundation will fund work in those areas, because they are kind of new areas, and there are things that the Board felt would not necessarily have gotten moving as fast as you would like, letting them come through, as you say, in the entrepreneurial approach.

They were put in as initiatives.

Mr. WALGREN. Would it be true also that, inasmuch as you do cut across a number of disciplines, even though you tell people that you are interested in that area, you still may not get the initiated proposal from one segment of the whole that you are trying to create?

Dr. GOOD. Mr. Chairman, that is possible, but it is improbable. The information of that sort moves through the academic community with unmeasurable speed, and such initiatives, the end result will be, they will be significantly oversubscribed, not the reverse.

Mr. WALGREN. They will be oversubscribed by proposals that you feel have all the necessary components to them. I understand an interdisciplinary project has a number of different components, and you are feeling that you will get the proper proposals with enough breadth in them, and enough participation from each of the several disciplines involved?

Dr. GOOD. Our experience, we have one very good experience in interdisciplinary programs. We have had the most experience in the materials science program. That is a very interdisciplinary program and requires inputs from a number of different kinds of people, and that program has been in place for quite a long time, very effective.

We have materials science centers, clusters, and if you notice, there is an initiative for 1985, not the same kind of initiative, but to allow groups of people to put in group proposals which will allow that kind of interdisciplinary action that you see.

The universities have moved reasonably well toward those goals.

Mr. WALGREN. Is that a serious problem?

Dr. GOOD. One simply has to look at the proposals that come in and be sure that you are getting the response that you expect in an interdisciplinary program.

The materials have been very good, indeed. We have gotten very good mixes of people.

Dr. KNAPP. In the materials science centers that we have, about half are operated out of engineering departments of universities and half out of the physics or chemistry departments, and that seems to work exceptionally well.

Dr. GOOD. You have to be sure that it looks like that again, particularly in the biological area.

Mr. WALGREN. Thinking of engineering, there was a National Academy of Engineering report which suggested that there are significant institutional problems, and that was a quote from them. They have to be addressed if engineering is to be strengthened at NSF. What is the Board's view of the institutional problems?

Dr. GOOD. I can attempt to give you the entire Board's view. We have discussed the whole engineering effort over a long period of time, and I am sure people have gotten very frustrated at us not being able to move more rapidly, but the difficulty in engineering in terms of the institutional problems is that the NSF, in the past, has focused on graduate programs.

We know how to fund graduate programs and take care of those students, but one of the difficulties in the engineering programs is that the professional degree that comes out of the engineering college is not a graduate degree. It is a BS engineering degree and one of the needs the engineering people feel needs to be addressed is, how do those people get the same kind, or at least some kind, of hands-on feeling of what modern engineering and, if you like, the cutting edge of engineering, is all about. There is the institutional problem in engineering, and they have also had another one, their teaching loads in recent years have been so high that the amount of time available for research has not been very high by their faculties and the whole institutional problem is a real one.

Mr. WALGREN. But then they are also thinking of institutional problems at NSF and wondering whether there are changes in the structure of NSF that could allow us to be more responsive?

Dr. GOOD. The NSF has changed its institutional function by creating the Directorate for Engineering.

I think it is the Board's feeling that, given time and developing the leadership in that directorate, that that is changing enough in the structure to make it go, because the Board, nor the Director, to my knowledge, puts any restraints on that directorate as to how it is to respond to engineering needs. So, if the engineering community gets the leadership there, they will respond as engineering would like and the mechanism is now in place to do that.

Mr. WALGREN. That leadership was not part of any of the unfilled spaces?

Dr. KNAPP. That Assistant Director happens to be an unfilled space at the present time, but not because of any action that the Foundation took.

The gentleman who was Assistant Director had an opportunity for employment at a much higher salary and decided to go to New York, and we do have a search under way for that Assistant Director's position, too, but it is not a presidentially appointed position.

At the present time, on the Science Board, I think we have seven engineers or people who are managers of engineering laboratories out of the Board complement, so I think that engineering is also very well represented on the National Science Board. There is no institutional problem with respect to Board advice on engineering and engineering-related topics.

Mr. WALGREN. Well, I want to stress again the interest of the committee in filling those spaces, regardless of the difficulties, and inasmuch as you cannot manage an organization without managers in place. I suppose we could pursue the reasons why they are not in place, but nonetheless, to assure the public of the best disposition of this effort, at some point we really have to be able to tell them that the slots have been filled for fear of being criticized of managing with unfilled slots, or not filling slots.

Dr. **Knapp**. No slots are unfilled. They are filled with people who are acting Assistant Directors, and I must take this opportunity to say that the people who are in those positions are doing an absolutely superb job of managing in the absence of permanent people. They are all very knowledgeable Federal employees who understand the system extremely well, and I am very pleased with the way it is going.

Mr. **Walgren**. You would agree that it would be more desirable for everyone's commitment and morale, I guess also, that these positions be filled with designated persons?

Dr. **Knapp**. Yes, I would agree.

Mr. **Walgren**. On the supercomputer business again, and particularly from the Board's standpoint, how does the Board view a $20 million initiative in the supercomputer area, inasmuch as there are certain views which we respect which would ask for a greater initiative?

Dr. **Good**. Mr. Chairman, I think the Board views that $20 million initiative in the following light: It is a start. I don't think anyone on the Board would argue that that is where you would like to be in 3 or 4 years in that area of supercomputing, but you have to begin with a program that you can actually accomplish, and we do hope that it can be leveraged.

We hope that $20 million can be leveraged significantly by providing some time off of existing facilities for university research people, and if you look at it from that point of view, it is perhaps not as large as we would like, but it is certainly a reasonable start if it can be implemented at that level.

You will see more demands to increase it as time goes on.

Mr. **Walgren**. $10 million is allocated in the mathematical and physical sciences, $5 million in the engineering directorate, and $2.5 million in biological, behavioral, and social sciences, and $2.5 million into astronomical, atmospheric, Earth, and ocean sciences. Could I ask for some development of how those funds will be used in each agency?

It seems noteworthy that a greater percentage is given to certain areas than others. I gather each must have different plans for the use of that money. If that is too detailed to talk about right now, perhaps we could receive a summary description of the anticipated use of those funds and explicitly, why $10 million goes to one agency versus $2.5 million to another and how they fit together.

Dr. **Knapp**. The funds were allocated on the basis of surveys done of the requirements of the various fields, the number of hours of computing time that they thought would be required, and then this was scaled to the overall size of the initiative.

I think that the distribution is, more or less, what you would expect considering the state of the art in the sciences represented by the various directorates, considering in the AAEO directorate they have their own facility at NCAR not included in that total.

I would expect that distribution to be modified rather dramatically as the initiative develops and as people learn how to use the facilities and as the pressures for proposals come in for supercomputer time.

Mr. BOEHLERT. Dr. Knapp, the allocation, I assume that they didn't all get what they asked for; is that a correct assumption?

Dr. KNAPP. That is correct.

Mr. BOEHLERT. What did they ask for that they didn't get? I am really worried.

We are not moving far enough and fast enough.

Mr. WALGREN. It would be fair to ask that question broken down by these portions of the distribution. In other words, we gave $10 million to this part of the agency. I would like to know what that part of the agency asked for.

Dr. KNAPP. Let me respond by first saying that we will provide for the record the development of these allocations the way they were developed.

[The requested information follows:]

DEVELOPMENT OF ALLOCATIONS—SUPERCOMPUTERS

The fiscal year 1985 estimates for the Advanced Scientific Computing initiative were developed in a manner somewhat different from those of our normal disciplinary programs. Instead of originating within each directorate, a cross-directorate task group developed them.

Surveys were made within each directorate of the number of researchers who potentially could immediately use access to a supercomputer to further their research. In addition, study results and recommendations were reviewed by Task Group members, and experts in various fields were consulted to gain understanding of the readiness of the various disciplines to utilize supercomputing resources.

These results were analyzed by the Task Group and a proportional share of representation established, which was then applied to the total amount to be included in the fiscal year 1985 Budget Request.

For example, the physical sciences have been computationally intensive for some time now. Many researchers in these fields are at the point where to do forefront research, the most advanced computing resources available are necessary. This has been less true to date in the biological and social sciences but, in these fields too, it is becoming clear that there is great potential for pursuing new and exciting research areas as supercomputing resources become more available and researchers are trained to exploit them.

Thus, in summary, individual directorates did not develop estimates for participation in the supercomputing initiative. They were developed centrally and then prorated for inclusion in directorate budget justifications. When less became available for the total supercomputing request, directorate shares were reduced proportionate to the original request and resulted in the following distribution:

	Million
MPS	$10.3
ENG	5.0
BBS	2.4
AAEO	2.4
Total	20.0

Dr. KNAPP. I would like to say some philosophical points. I think that we are in a situation where, and I believe that I said this on Friday too, we are in the situation where the university users of supercomputers have not had access to these, so in a true sense, they don't know what they don't have and I believe that the desire or the usefulness of these computers, computer time is incredibly big.

Any estimate we would make at the present time of the application of these computers in 10 years will be an underestimate in any guess. So we really have to be quite flexible in the way that we divide the allocation of time, being very sure to nurture the use of this very, very powerful tool, so that all of the disciplines get a chance to work their systems and their studies into the use of these facilities.

For example, at the present time there is only one economic model which uses a supercomputer for its generation. I think this is in Minnesota, but I am not positive.

I, personally, have used supercomputers, and I think that the application of very large scale computing to problems like this is very promising.

Not every economist would agree with that, but that is my view. We have to work very hard to get the physicists, chemists, psychologists, everyone, working together to develop ways to use this powerful tool to answer a broad variety of the questions which, in fact, may use the same kind of mathematics to answer questions.

I am very excited about the application of supercomputers to science in a university setting, and I think that at the present time it is very difficult for us to give you a definitive answer on how much the demand will be and how much science will change if we make these machines available.

Dr. Good. One other comment about those. There is another aspect that is really very important, and that is that these machines are not useful without a very highly qualified and versatile staff, particularly in a networking type of environment where you have one machine off site and university personnel are going to tie into that machine and use it.

That means at the facility where that computer is, you are going to end up with just about the same investment in people and staff that must be maintained over a very large period of time as you are in the hardware.

In fact, there are some examples where people have managed to get the computer but have not had the recurring resources in place to provide the staff and the machines do not become totally usable, so it has to go together. This is not just a hardware question.

Mr. Walgren. Well then, if I might ask, along with the idea of how those individual amounts tie into a network, I guess what I hear you saying is we are going to do a network and have one center, and yet we have these amounts parceled out, and in amounts from $10 million to $2.5 million.

What is the rationale of parceling that out and how does that tie to the network which to me is sort of a unitary phenomenon rather than one of separate individual efforts?

Dr. Knapp. The way we propose to do this, well, first of all, it is in a very active state of development at the present time, the way we will accomplish this.

It is not set. We don't have a complete plan. We have an advisory committee coming back on the 5th of March with the first set of plans.

In our minds, what we see is the $20 million used to support a network and a few, one or two in initial stages, supercomputer centers which are tied into this network, and then a researcher, and that is the $20 million.

Now, a researcher from, say oceanography, wishes to make a calculation, and he estimates that it will take 10 hours of central process time on a supercomputer. That time is there, provided, and the experts that support it; the network is there, and he doesn't get an allocation of money to him to buy time. He gets an allocation of time in that system, and he can then access for his research 10 hours of central processer time. That is the award that the National Science Foundation will provide to him, not money to buy time, but time in a facility which is supported by the National Science Foundation overall. So, in a sense, the money will not flow through the particular directorates, but the time will go through the directorates to be assigned. And that allocation of time can be shifted very easily as the pressures from one discipline or another increase or decrease.

If we are in a situation of satisfying 100 percent of the requests from physics and only 10 percent from oceanography, we will clearly shift our allocation.

Mr. BOEHLERT. We are going to get for the record the request from the various disciplines?

Dr. KNAPP. No; I think what we will try to put for the record is how the distribution was generated.

Mr. BOEHLERT. I would like to know what the Directorates requested.

Dr. KNAPP. I am not sure we did the allocation that way. We had a central group poll the directorates and make questionnaires to all scientists associated with the Foundation.

Dr. Hayes.

Dr. HAYES. This particular initiative is a crosscutting initiative and, in the planning, it was developed as a crosscutting initiative. It was worked in that way, not as an initiative that came up individually from the directorates.

We have, in the planning, and I think this will be quite explicit in the plan, for instance, that we are working out at the present time, there are planning documents and requests that come up through the directorates. In addition to this, there are activities which cut across all of the directorates, of which this would be an example. Biotechnology would be another example of long-term research related to it and would be an activity that cuts across all the directorates and, in the planning stage, they come up quite separately for budget decisions. As they are discussed by the Board and Foundation management, one then decides the extent to which it is appropriate for each directorate to participate and, in this particular case, it was through the crosscutting——

Mr. BOEHLERT. Crosscutting initiative, is that the phrase?

Dr. HAYES. Yes.

Mr. BOEHLERT. This morning the Assistant Secretary of State told us, "Over in Lebanon we are redeploying our military assets for their more effective utilization."

I won't tell you what I then said.

Where did that $20 million come from, within NSF, or did you ask for more from OMB and did they cut you back?

Dr. HAYES. That came up on Friday, and there are two elements to this. One, there is the Bardon-Curtis report, submitted to this committee, which had estimates of the need running in the $100 million range. The Board and the management, in reviewing that material and preparing this initiative for the 1985 budget, came up with a package which was about half of that total amount, representing a request. To put your question in perspective, those amounts, at that particular stage, did not represent requests of particular directorates.

As this initiative was being developed, we were trying to establish the extent to which the various disciplines are prepared to participate in this supercomputer at this time.

We took into account that some disciplines are much further along because of their past history and access to supercomputers in the discipline generally and, in some cases, through other agencies. For instance, in the physical sciences, as you may know, some physical scientists, chemists and physicists have access through collaborative activities to computers at National Laboratories, and they are further along and are likely to make greater use of the supercomputers in the initial stages. But as mentioned, we expect that with time and as other disciplines gain experience with supercomputers, they will be able to participate to a greater extent because they will realize what they can do in their own discipline, and the quality of the proposals that we can put in to do research using supercomputers will make them very competitive with what people could propose in physics, chemistry, materials research at this time.

Mr. Boehlert. Dr. Knapp, you indicated we had one or two centers. How are they going to be selected, any feeling for that?

Dr. Knapp. We will solicit proposals from universities for the establishment of centers or proposals to expand existing centers to fit these requirements.

These will be judged on the basis of peer review, as we always do in the Foundation, and the winners will be selected. That will include the management plan, the way they would propose to fit into the network that we would be establishing, and all of the technical aspects of the provision of supercomputer time to remote users.

Mr. Boehlert. During this year?

Dr. Knapp. 1985. We are starting this initiative in 1984. We have a solicitation for proposals for providing computer time to remote users from existing centers. We have that out. The proposals are back and are being reviewed at the present time and, if some of these proposals are responsive, we will have an award in 1984 for the provision of some computer time to university users over networking within. Unfortunately, at this time, we will have to use the existing networks, which are either the CSNET, the ARPANET or TELENET, which is a commercial network.

We feel the problem is so pressing that we don't wait for the $20 million initiative in 1985, and we get started with $6 million in 1984. The moneys for that part of the initiative have been designated by the directorates themselves.

They were not an initiative which came forward from the budget discussions of last year.

We think we must get going, so we pooled the resources which were designated within each of the directorates for 1984 into an initiative.

Mr. Boehlert. What is the history of the 1984 authorization? Didn't we, in subcommittee, add $100 million for instrumentation and that was knocked back to $50 million in full committee and, when everything wound up, the appropriation was something like $15 million?

Do you know the history of that? I remember Mr. Brown of California and I last year, and I was a rookie then and still am, we did move in subcommittee $100 million amendment for instrumentation.

Dr. KNAPP. There is a $15 million initiative on high technology instrumentation, of which some is computer, some is networking, and some is things like the electromicroscopes I talked about earlier. It is across a number of disciplines and a number of kinds of instruments.

Mr. BOEHLERT. We will try again this year.

If I had the people from the university research centers before me today and asked them if they thought $20 million was enough and they generally are enthusiastic about the manner in which you are proceeding, I think I might get a different answer.

Do you think I would?

Dr. KNAPP. I think we have tried to indicate that we feel this is an extremely important problem and that we want to get on with it as fast as we can.

Mr. WALGREN. As I understand some of the dollar amounts involved, you are doing $6 million in 1984, when the Bardon-Curtis report asked for $70 million and you are doing $20 million in 1985 where the Bardon-Curtis report suggested $188 million. So there is a great discrepancy in the views as to the size, versus what in management's view is able to be done.

Your request was something like $47 million to OMB, so we just want to lay out for the record these differences in hopes that pressures will develop to go in the right direction.

If I could ask one other question along this same line. Perhaps the staff can followup on these questions and really straighten them out if they are difficult to have answered. It may be that your explanation that time is being bought makes the question academic.

As I understand the budgeting process, you do have a zero-based budget that is sort of stacked on top of each other and you can reshuffle the cards and tell us what would drop out if you had to do something else. The question then would be if the Congress increased the amount for supercomputers to $50 million, and in the alternative $100 million, what would be accomplished by adding that money to the supercomputer effort that is not going to be accomplished at $20 million, and what would be left out, assuming you had to cut some place else?

You do submit a stack of cards to OMB and you can cut that deck wherever you choose, so if you could respond to that kind of alternative funding, it is very important for the Congress to know what the alternatives would be that we would be dealing with.

Mr. BOEHLERT. As the Secretary of State would say: How would you redeploy your assets?

Dr. KNAPP. In our submission to the OMB, we did not have a prioritized set of requirements. We submitted one budget and negotiated on that, so it will be somewhat difficult for us to generate this, but we will try to generate a response.

[The requested information follows:]

SUPERCOMPUTER INITIATIVE PROJECTED PLANS AT VARIOUS LEVELS

At the $20M level, which is the President's request level, our plans call for allocating the funds in approximately the following manner:

$10M for provision of access to supercomputers through allocation of blocks of time. Depending on the amount required for the blocks of time effort, we would hope to initiate one university-based supercomputer Center.

$5M for further study of networking options and priorities and initial implementation of networking capability for supercomputer users.

$5M for provision of local user equipment necessary for remote access to a supercomputer or access to appropriate networks and experiments with broad-band networks.

This allocation is preliminary and could change somewhat as our plans develop. The advice of our Advisory Committee for Advanced Scientific Computing will be especially important in assisting us to determine the proper mix of activities in fiscal year 1985 and beyond.

At the $50M level we would initiate several (3) Centers and accelerate development of networking. At the $100M level we would add effort to both of these activities as well as provide adequate local user access equipment. It should be pointed out, however, that it would be difficult to "ramp up' our program effort in one year. The quality of effort for which we are aiming demands careful planning to ensure a coherent program that can provide high quality resources to our research communities.

If the program recommended for supercomputing were at the $50M or $100M level and no additional funds were added to the total Administration request for NSF, the agency would face severe problems in identifying cutback areas. In developing the Administration's request, priorities were developed which resulted in a balanced NSF program for fiscal year 1985. Pumping significant additional funds into one area, such as supercomputing, seriously disturbs this balanced approach. Each directorate would be forced to review their programs to seek out areas to be cut. In general this would result in fewer grants to new investigators, reduced support of instrumentation, and a net drop in numbers of awards since the awards in the supercomputing activity will be few but large.

Mr. WALGREN. It would be helpful to the committee to know what we are sacrificing and what we might be gaining.

It is my understanding that we would like to see this film at this point.

Mr. BOEHLERT. I came for two reasons. One, to hear Mr. Knapp and Dr. Good and, two my staff told me it was a matinee performance.

Dr. KNAPP. It is; unfortunately, we don't have popcorn.

Mr. WALGREN. This film illustrates why the Science Education Directorate never should have been disbanded in the first place. I understand there are some people in the audience that would like to see this film also. Then I have some more questions after that.

[Film shown.]

Mr. WALGREN. I have a couple of other areas to deal with.

It was brought to our attention that NSF has at least had sort of an arm's length distance between itself and the interagency acid precipitation task force. There was a reason given for that, and it was said that the peer review screening that goes on doesn't allow some NSF money to really get involved in the interagency task force effort, and that NSF took the position that since these other agencies were provided funding in this area, they were not really all that interested in participating.

Is that a fair statement, or what is NSF's relationship to that interagency task force and how much are we participating?

Dr. KNAPP. We are a part of the interagency task force on acid rain, and we think that we play a very important part in that task force in that we do—our contribution is in basic research, the basic chemistry and formation of the acid rain.

I would like Dr. Rabin, BBS Assistant Director, to answer that question for you.

Dr. Rabin. The acid rain research that we are involved with is related to the energy security act which specifies an acid precipitation task force, which was set up to be chaired jointly by the Department of Agriculture, the Environmental Protection Agency and NOAA.

The Foundation has a role in the membership of that task force, but does not have a specific voice in setting agendas in which the Foundation takes a specific part other than, as Dr. Knapp has indicated, the support of research which is related, and that is basic research, so we have, in effect, two major parts of the Foundation involved with it.

One, the Astronomical, Atmospheric, Earth and Ocean Sciences Directorate, and BBS Directorate.

We have a distribution, or we could supply it for the record, of the funds and projects which the Foundation did provide in 1983.

Ms. Bach [counsel for the minority]. In that regard, if you were to calculate what NSF's basic research is in acid rain, would you count in all of the work that is being done at NCAR, because they have some terrific research going on out there?

Dr. Rabin. Yes, the distribution which I would provide you would include the NCAR contribution. Currently, as far as I can tell, about $69,000 worth.

Mr. Walgren. The concern of some people was that, on the task force as a whole, much of the research is not getting to universities, and is being kept somewhat perhaps on a direct contract basis or in-house basis by some of the agencies involved.

The NSF is seen as the only part of the task force that can really draw out the universities and create an involvement in the acid rain problem, but, given the discipline by which all your research is funded, it is not quite able to be focused on a problem like acid rain. We would like to ask the Science Foundation to look at its participation in that whole range, knowing that there may be some very good things that could be done, and there is some view that the Science Foundation could be doing some things that it is not.

I ought to raise that with you and we will have the submission that you have, and please think about that and wonder whether or not there is a greater role that NSF could play in the acid rain problem.

Dr. Knapp. There is probably a greater role that the university community could play in the problem. Whether the NSF support is the proper way to do it or through other agency support to universities, I agree, we will try to make a submission on what we do at the present time.

[The requested information follows:]

NSF SUPPORT OF RESEARCH RELATED TO ACID PRECIPITATION—FISCAL YEAR 1983

[Dollars in thousands]

Program	Amount	Number of projects
Biotic systems and resources	$314	7
Atmospheric sciences	251	15
(NCAR—NSF)	(69)	
Earth sciences	141	4
Chemical and process engineering	68	3
Materials research	51	5
Policy research and analysis	30	2
Ocean sciences	14	2
Civil and environmental engineering	5	1
Total	874	39

Mr. WALGREN. We had mentioned earlier the materials area and the cross disciplinary effort that is being done there. Other parts of the government do materials research, particularly the Department of Energy. How do you make sure you don't do the same things?

Dr. KNAPP. The interaction in that particular community is very good.

We have, I think, a single community, and I know something of it. They share instruments between the Department of Energy supported centers and the NSF supported centers; NSF grantees work on Department of Energy facilities; and there are Department of Energy grantees or supported people who will, from time to time, work on NSF supported facilities.

We have a committee of the National Academy of Sciences, right now, looking at the overall problem of materials research, the socalled Seitz committee, the chairman of the committee, who is looking at facility needs in materials science.

The coordination is really relatively informal, but I think quite good.

Mr. WALGREN. OK. The initiatives on centers for crossdisciplinary research in engineering funded at $10 million, what kind of an effort will that get us?

Dr. KNAPP. The $10 million effort; these centers are envisioned to be about, a million in funds expended for each center, so with $10 million, about 10 centers, and that is after a certain number of years of development.

We may, perhaps, get more than that, but I doubt if we will get them started in 1985.

I think that this is an excellent initiative. It addresses an extremely important problem in engineering, and I think we will be quite pleased with the results.

Mr. WALGREN. When we go into these big construction projects like the very long baseline array, how can we be assured in some way that that effort will not draw the life blood from other ongoing efforts in that same directorate?

When we get into some of these very expensive construction projects, we like to think that we were doing it with additional money, and that we are not unconsciously undermining areas that we are presently supporting?

Dr. **Knapp**. That is a very important part of the balancing that we do when we come forward with the budget submission to you.

It is very important in an area like astronomy that we not ruin the core program to have another instrument. It is very important that we go forward with new instruments, or we are left in the backwater of science.

The discipline is very squeezed in the sense that we require a real studied look and sacrifice on the part of the overall program and that some of the funds which are used to support the new initiative are taken from the ongoing program. But, without additional funds, we would never put forward the request for the very long base line array program.

It is a very well-scrubbed proposal.

I could ask Dr. Bridgewater, the Assistant Director for AAEO, to elaborate on that.

Mr. **Walgren**. We would like a submission in writing and in the interest of time we will ask for that.

[The requested information follows:]

EFFECT OF VLBA FUNDING ON AAEO CORE PROGRAM

The administration proposal for construction of the VLBA takes place in the larger context of wishing to provide simultaneously for adequate continued support of the core programs of the directorate and for an initiative that has achieved wide recognition as the highest priority for ground-based astronomy. The Foundation is very sensitive to the need for striking an appropriate balance between expanded capabilities that will allow entirely new and important research problems to be attacked for the first time and the necessity of maintaining the health and vigor of important scientific programs already in progress so that they not be interrupted prematurely and waste scientific and financial resources.

In the case of proposed funding levels for the other disciplines in the directorate, the Foundation believes that it is responding appropriately and vigorously to the needs of the sciences, and that substantial progress will be made in improving the effectiveness of the earth, atmospheric, and ocean sciences. In astronomy, much of the increase in the overall program of 19.5% is deliberately directed toward starting construction on the unique Very Long Baseline Array. This project has engendered widespread enthusiasm in the field, and has the explicit endorsement of the well respected Astronomy Survey Committee as the most important instrument needed for ground-based astronomy. Its importance and probable productivity are so high as to justify smaller increases in the astronomy base program, considering the long-term beneficial consequences the instrument's availability will have for the vitality and productivity of the science.

Mr. **Walgren**. On science and engineering education, the committee passed a substantial mathematics and science education bill last year, $450 million in total.

Could you outline how the Foundation's proposal this year responds to the thrust of that legislation?

Dr. **Knapp**. In various parts of our science and engineering education program, we are responding to particular areas of the bill that you passed. That is H.R. 1310; is that correct?

In section 103 of that bill, we address NSF honors teachers workshops and demonstration workshops, and, in section 105, we have learning and teaching research in the biologic, behavioral and social sciences from engineering education.

In section 204, we address engineering and science personnel through our ongoing research programs, research related activities of the Foundation.

In section 205, the Presidential young investigators program and the engineering centers, and precollege science education has the television program, 3-2-1 Contact, as one of the things we support which fits in that same section. We also are initiating at the Foundation, this year, expanded research in primarily undergraduate institutions programs which also relate to portions of the act which you passed. So we are responsive in what we are doing within the Foundation.

Mr. **Walgren**. Thinking about earthquakes for a second, the fiscal year 1984 appropriation cut the societal response earthquake program $2.3 million to $800,000. Have we lost anything in that reduction, and what are we requesting for societal response in 1985?

Dr. **Knapp**. Perhaps I should deflect that question to the Assistant Director for Engineering who carries out these programs, Dr. Hall, Dr. Butcher representing Dr. Hall.

Dr. **Butcher**. The program has been cut from a requested $2.3 million to $800,000 in this current fiscal year.

That represents a cutback in a number of activities. The success cutoff point has had to be raised. We are requesting $900,000, a small increase, to bring that program along at a level more or less the same as fiscal year 1984.

Mr. **Walgren**. What happens when you raise the level of the cutoff?

Dr. **Butcher**. Some of the people who would otherwise be above the cutoff will not get grants; only the very superior ones will get grants. There is a band which would have been funded but will not be funded with the reduced funds.

Mr. **Walgren**. Let us know what kinds of value are we losing. We wanted to ask whether a large engineering shake table is in our plans at all, or is that not—maybe that is not the best question.

[The requested information follows:]

The effect on the Earthquake Societal Response Program from raising the cut-off point for grants:

Four topical areas have been given emphasis in Societal Response Research: (1) the social and economic aspects of mitigation, (2) preparedness, (3) disaster impacts and responses, and (4) research on hazard information dissemination. While all four topics are important, up until fiscal year 1984 more emphasis was placed on research related to mitigation and preparedness, in part because less is known about these subjects. After having reached $2,288,000 in fiscal year 1983, Societal Response Research was reduced to $800,000 in fiscal year 1984. The budget cut will require us to give even less attention to the other two topical areas than we feel is desirable, including work on such important issues as family and community recovery from disaster and the role of the mass media in disaster. Our previous budgets had enabled us to strike a nice balance among the four topics in recognition that significant knowledge gaps existed in all of them when the field is compared with more established disciplines. However, even the highest priority areas will suffer significantly as a result of the fiscal year 1984 budget cut. For example, few projects can be supported using cost-benefit methodology in order to identify the more effective earthquake hazard mitigation measures used in the country, which is one of the program's main goals.

In addition to reducing the scope of the program, we have also had to think in terms of supporting more modest and shorter term projects in fiscal year 1984. For example, because they are expensive, large-scale projects, which are often necessary in order to acquire comprehensive data that allow useful generalizations to be made, are unlikely to be supported. For similar reasons, even though they have the potential for producing significant results, studies that would monitor mitigation and preparedness efforts in threatened areas over a long period of time are unlikely to be supported in fiscal year 1984.

Presently, the United States is the world's leader in the societal response to natural hazards research field, with countries like Japan, Italy, and Great Britain being close behind. However, reductions in the scope of Societal Response Research at NSF will soon result in the U.S. giving up its advantage in this area to other countries.

Dr. KNAPP. The large table is not in our plans. We are required to use the Japanese facility for studies of that kind.

Mr. WALGREN. Do we use the Japanese facility?

Dr. KNAPP. Yes, we do.

Mr. WALGREN. Dr. Good, it is my understanding that the National Science Board suggested a commission on information policy at some point last year. Has that idea developed?

Dr. GOOD. No, the status of that information policy, at the moment, is that we have asked for staff review of information science which we should have some results from within the next, what is the deadline on that?

Dr. KNAPP. Mr. Green.

Mr. GREEN. Within the next 30 days.

Dr. GOOD. As some of you know, Mr. Brown, who is on your committee, is extraordinarily interested in that topic, and Dr. Branscomb and I visited with him last year, where he chastised us seriously for our neglect in this area, and we have started to look at the issue.

The NSF had a task force essentially a commission, which met back in 1977, and the difficulty that happened at that time is that the Commission really did not get out any indications of exactly where the Foundation should go. There was a great deal of discussion as to where the commercial sector was at that point in time. We also got tangled up in the whole argument about science information versus information science, and we never quite got ourselves extricated from that mixture. The interest in that area has not been as great as some of us on the Board would like, and we do have this information report coming out shortly.

We have some hope that this will, indeed, become one of the June issues for the Board. If that is the case, you will see a policy statement and perhaps an initiative within that area within the next year.

Mr. WALGREN. I see.

Dr. GOOD. Please tell Mr. Brown that, too.

Mr. WALGREN. Going back to an area we have touched on before, which is this Management Information System and the STIA programs. I understand that some STIA programs have been increased, and others have been held somewhat at the same levels, and that you do feel that many of the directorates do contribute to the goals that the STIA programs are designed to serve and want to track those efforts in the Foundation, so that we can make a judgment as to what the magnitude of the overall effort in each area is.

I am wondering whether I could ask for a submission of some kind, regarding elements of STIA such as the University Industry Cooperative Research Program, Intergovernmental Science and Technology program, the minority programs, the International Cooperative Scientific Activities. If you feel that they are being served by mainstream directorate efforts, could you submit what the aggregate effort would then be in each of those areas?

[The requested information follows:]

STIA Coordinated Efforts

Policy guidelines have been established for the Foundation that are intended to maximize the contributions made by the several NSF directorates to the achievement of NSF-wide goals, without compromising the integrity of the STIA programs and their ability to respond to the needs of the constituencies they serve. The ways in which this is done necessarily vary with the particular circumstances in each case.

SUPPORT FOR WOMEN AND MINORITY SCIENTISTS AND ENGINEERS

These programs already work closely with the discipline-oriented programs in their peer review procedures and in seeking to bring their clientele into the mainstream of NSF research support. Accordingly, their status remains unchanged, and their operations are funded entirely within STIA at the following levels:

[In millions of dollars]

	Fiscal year—		
	1983 actual	1984 estimate	1985 request
Visting professorships for women	$1.94	2.0	$2.0
Research opportunities for women			0.5
Minority Research Initiation	1.98	2.5	2.5
Research Improvement in Minority Institutions	1.98	2.5	2.5

At the same time, each of the research directorates (including STIA) has been asked to develop a plan that will result increased program support for research conducted by women and minority scientists and engineers. While no specific dollars have been allocated for this purpose, the plans are expected to result in significant increases for these groups within the mainstream of NSF activities. A system for tracking and reporting on the results is being established.

SUPPORT FOR PREDOMINANTLY UNDERGRADUATE INSTITUTIONS

In this case, principal responsibility for increasing NSF support for research at predominantly undergraduate institutions has been assigned to the disciplines-oriented directorates; STIA's role is one of tracking, coordination and outreach to this constituency. The activity includes all NSF awards to these institutions, including standard research awards, research instrumentation (incorporating a line item program for this specific purpose that was previously managed by STIA), and research opportunity awards to involve small-college faculty in projects supported at major research institutions.

Targets have been established for this activity that will increase total NSF support for predominantly undergraduate institutions from $36.8 million in fiscal year 1984 to $42.4 million in fiscal year 1985. Included in this total is a target for fiscal year 1985 of $5 million for research equipment, up from $4,573,000 in fiscal year 1984.

SUPPORT FOR INTERGOVERNMENTAL SCIENCE AND TECHNOLOGY

The NSF Intergovernmental Science and Technology Program has been located in STIA since fiscal year 1982, and is not affected by the new management plan. Budgets for this Program for fiscal year 1983 and fiscal year 1984 and the NSF request for fiscal year 1985 are unchanged, at $500,000 in each year.

SUPPORT FOR INDUSTRY/UNIVERSITY COOPERATIVE RESEARCH PROJECTS

This STIA-coordinated program consists of research projects that are jointly funded on a 50-50 basis by STIA and the discipline-oriented research directorates.

Technical evaluation of proposals is carried out by the research directorates while judgment of other program objectives is accomplished by STIA. Final decisions on a project are made jointly. In both fiscal year 1984 and fiscal year 1985, the STIA budget for this program is $7.0 million, with an equal matching amount provided each year by the research directorates. Consequently, the aggregate budget for this program is $14.0 million in each of these two fiscal years.

SUPPORT FOR INTERNATIONAL COOPERATIVE SCIENTIFIC ACTIVITIES

Almost all units of the Foundation participate in formal or informal international projects, and they contribute extensively to the agency's overall level of funding for international activities. This aggregate funding is far greater than funds provided specifically in STIA for international programs, and is estimated to amount to $84.6 million in fiscal year 1984 and $90.2 million in fiscal year 1985. Attached, for the record, is a table appearing in the Budget Summary (page NSF-21) of the Foundation's fiscal year 1985 budget justification. This table shows funding for international science activities in three categories: 1. Cooperative Research—These are projects (research, seminars, exchanges) supported under bilateral agreements entered into with another country by the U.S. Government or the National Science Foundation; 2. International Related Research Projects—These are research projects supported by the discipline-oriented directorates that have significant amounts of international activity and are performed under the auspices of an international program or agreement other than bilateral agreements; and 3. Special Activities—These are generally large, focused international activities having special features that distinguish them from regular international projects.

NSF SUPPORT OF INTERNATIONAL SCIENCE ACTIVITIES

[In millions of dollars]

	Fiscal year—			
	Actual 1983	Current plan 1984	Estimate 1985	Difference 1985/84
Cooperative research:				
STIA	$3.6	$3.9	$3.9	—
Disciplinary activities	5.3	5.9	6.8	$0.9
International related research projects: disciplinary activities	17.6	20.2	23.2	3.0
Special activities:				
Antarctic research	18.9	22.3	22.8	0.5
Ocean drilling	21.0	26.3	27.6	1.3
International science organizations	1.0	1.1	1.1	—
Indo-U.S. initiative	—	2.0	2.0	—
Special foreign currency	3.1	2.9	2.8	−0.1
Total	70.5	84.6	90.2	5.6

Dr. KNAPP. For some of those areas, our information system, being not complete, may have a difficult time producing that for all, but we will certainly produce estimates of all of the areas in which you have just mentioned.

Mr. WALGREN. And then another question is in the Antarctic program, we have picked up some $6 million of retirement costs formerly funded by the Department of Defense.

It strikes me as sort of an odd function for NSF funds to go to military retirement. Is there a real reason for that, and should we be resisting that?

Dr. KNAPP. We should not resist it. The requirement of the law, and the Presidential directive which gave responsibility for the entire Antarctic program to the National Science Foundation requires that we pay all costs.

We have been paying military pay but not military retirement, not a contribution for military retirement. We are now picking up all costs for the military which are associated with the Antarctic program.

Mr. **Walgren**. I see. With respect to the proposed withdrawal from UNESCO, we touched on this the other day, and I confess not to remember the record that might have developed, but are we making estimates of what we might lose if we do withdraw from UNESCO and is the National Science Foundation making estimates of what we ought to do to fill that gap?

Dr. **Knapp**. Yes, we are.

Mr. **Walgren**. Could you submit some of those estimates for the committee's review?

Dr. **Knapp**. On Friday, the record shows that we are doing an inhouse study of it, of what we lose if we withdraw from UNESCO, what activities would have to be accounted for in some other way. Also, the National Science Board International Subcommittee is going to look in some length at that whole question, so that may not be—the Science Board's response may not be immediate, but we will bring it to you as soon as we have some results.

[The requested information follows:]

UNESCO

In August 1983, the Department of State asked the National Science Foundation (NSF) to coordinate an interagency working group to study UNESCO natural sciences activities. A draft report was transmitted to the Department in October 1983, for use in an ovreall study. The study has not yet (28 February 1984) been released by State.

In its part of the study described above, NSF examined its own involvement with UNESCO projects and found it minimal; the main participants are the U.S. Agency for International Development, Agriculture, Commerce, and Interior. NSF participates in the Oceanographic Data Exchange of the Intergovernmental Oceanographic Commission, a UNESCO science program. U.S. withdrawal for UNESCO does not automatically imply withdrawal from the Commission.

NSF provides support to the National Academy of Sciences for U.S. activities in the International Council of Scientific Unions (ICSU). This includes payment of U.S. dues to ICSU. Although ICSU is not a UNESCO organization, it receives partial support (about $500,000 annually) from UNESCO. If UNESCO finds itself less able to support ICSU because the U.S. support of UNESCO has stopped, ICSU dues may rise. There is currently no basis for predicting this result.

The National Science Board, through its Subcommittee on International Science, has begun to study U.S. participation in UNESCO scientific activities. No results are available at this time.

Mr. **Walgren**. And also if you could touch on the Foundation's planning and evaluation effort. It is my understanding that that has been eliminated in STIA. Are you assuming that on a larger overall umbrella level?

Dr. **Knapp**. Yes, we are. The planning and evaluation money was spent on studies for various organizations, such as the National Academy of Sciences, the Committee on the Science and Engineering Public Policy Committee [COSPUP], things of this general kind.

We feel it is better to have the various disciplines of science who participate in those particular studies pick those up as they are related to their discipline and not have an umbrella fund, so that is being taken care of.

We don't expect the activities funded under that program to be diminished. We just expect them to be spread to the recipients of the studies themselves.

Mr. **Walgren**. And with respect to policy research and analysis, that is not done under the traditional peer review solicitation, but rather targeted on agreements with six organizations, as I understand it?

Dr. **Knapp**. That is not quite accurate.

The policy research and analysis part of the NSF has three methods of doing business, including their own in-house studies. They have a few studies which are given to organizations with which they have contracts for very quick studies by external organizations, but the bulk of their research funds are expended on peer review proposals which are received and peer reviewed and awarded.

In discussing this problem with my staff, the number, the fraction quoted was three-quarters of the programs are peer reviewed, one quarter require a faster turnaround and are done with contractors.

Mr. **Walgren**. I see. That exhausts my questions. Does anybody have anything further?

Ms. **Bach**. You exhausted mine, Mr. Chairman.

Mr. **Walgren**. Well, let me express our appreciation. Certainly the committee will have no excuses that we don't have some initial contact with you on a number of points that we should be aware of, and it is our responsibility to try to follow up and know what is happening. So let me thank both of you. Dr. Good, it was especially nice to have you here, and Dr. Knapp, we certainly appreciate your participation in this year's effort.

[Whereupon, at 4:35 p.m., the subcommittee was adjourned.]

1985 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

TUESDAY, FEBRUARY 28, 1984

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2 p.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Brown, McGrath, Dymally, Sensenbrenner, Skeen, and Gregg.

Mr. Walgren. The subcommittee will be in order.

The focus of these hearings is the overall research priorities of the Foundation and the emerging interdisciplinary areas such as supercomputers and the proposed centers for cross-disciplinary research in engineering, along with university instrumentation, biotechnology, and the general subject of science and engineering education.

The hearing today will give us the opportunity to hear the views of a number of distinguished scientific and technical organizations who are not directly part of the National Science Foundation Administration. Two panels of witnesses will be present today. The first is made up of Dr. Anna Harrison, who is representing the American Association for the Advancement of Science, along with Dr. Robert Rosenzweig of the Association of American Universities. Dr. Rosenzweig is also representing a number of other—to wit, five—additional associations, and we want to express our appreciation to those organizations for, first, coming up with a consensus statement that can be more easily considered by the committee, and, second, to congratulate them for being so concise as to come up with one statement out of five.

I think that also says something about the influence of Dr. Rosenzweig in the whole picture of things, and we appreciate your being here today.

The second panel, which we will come to a little later, consists of Dr. Russell Drew, who represents the Institute of Electrical and Electronic Engineers, and Dr. Henry Aaron, who will testify on behalf of the Consortium of the Social Science Associations.

I do want to express very directly how much the committee members appreciate the work that goes into preparing testimony, both written and oral. It is the only thing that keeps us on a sound basis in many ways, and we do appreciate, on a very direct level, the contribution that you make to the process that we are all engaged in.

I would like now to recognize Mr. Sensenbrenner for opening thoughts.

Mr. **Sensenbrenner**. Thank you very much, Mr. Chairman, and I appreciate your recognizing me for a few brief moments.

I would like to join with Mr. Walgren in expressing appreciation of the subcommittee for our first two witnesses in being clear, concise, and together.

The fiscal year 1985 National Science Foundation authorization is a very important bill in terms of determining the direction that science and scientific engineering education will be going in for the next several years.

There is one issue that I would like to express my concern on at this time, and that is the issue of having the National Science Foundation fund various projects based upon the scientific merit of those projects as determined through a peer review process, rather than using the political pork barrel to determine who is the beneficiary of the Federal funds that are available.

Unfortunately, last year the full House of Representatives kind of dipped its hand in the pork barrel in funding a couple of projects that didn't even make application for the peer review process. Frankly, I think that that is unfortunate, and I think that this subcommittee and the full committee are to be commended for not getting involved in that kind of politics.

However, I do think the time has come, given the unfortunate precedent that was set, for the House of Representatives to reaffirm its faith in the scientific peer review process. The gentleman from Kansas, Mr. Winn, and I have introduced a resolution to place the House of Representatives on record along those lines.

I am gratified that Dr. Rosenzweig's statement specifically endorses the resolution that Mr. Winn and I have introduced, and hopefully, with the support of the prestigious institutions that both of our first witnesses represent, there will be sufficient support on this committee to send it to the floor and, hopefully, get our hands out of the pork barrel this year.

Thank you.

Mr. **Walgren**. Thank you, Mr. Sensenbrenner.

Mr. Brown, any opening thoughts?

Mr. **Brown**. No, thank you, Mr. Chairman.

Mr. **Walgren**. With that, let's turn to the panel and first Dr. Harrison. We appreciate your coming very much. Your written statement and anything that you would like to submit to the committee will be reproduced in the record as a matter of course. We will be very interested in your presentation focusing on the highlights of your testimony in a way that you feel is most effective. So welcome to the committee.

[A biographical sketch of Dr. Harrison follows:]

Anna J. Harrison: Professor Emeritus Chemistry, Mount Holyoke College

Degrees:
Doctor of Philosophy (1940), University of Missouri, Physical Chemistry
14 Honorary Doctor of Science Degrees

Academic Appointments:
Distinguished Visiting Professor, U.S. Naval Academy, 1980
Department of Chemistry, Mount Holyoke College, 1947-1979
USAID Banaras Hindu University, India, Summer 1968
Sophie Newcomb College, Tulane University, 1940-1945
Rural school teaching, Missouri, 1933-1935

Research Appointments:
Collection and Detection of Toxic Smokes, Office of Scientific Research and Development Project at University of Missouri, 1943-1944
Infrared Absorption of Quartz, Corning Glass Works, Summer 1945
Research in Flash Photolysis, Cambridge University, 1952-1953
Photolysis in the Far Ultraviolet, National Research Council, Canada, 1959-1960

Publications:
Journal of the American Chemical Society, Journal of Physical Chemistry, Review of Scientific Instruments, Proceedings of the Royal Society, Journal of the American Ceramic Society, Journal of Chemical Physics, Journal of Chemical Education, Encyclopaedia Britannica, Science, Journal of Science, Technology and Human Values

Professional Service:
President, American Association for the Advancement of Science, 1983-1984
Convener and Cochairman AAAS-UN Panel of Experts, Science, Technology and Women, 12-16 September 1983
Editorial Board, AAAS publication, Science 80, 1979-1982
Phi Beta Kappa Visiting Scholar, 1979-1980
President, American Chemical Society, 1978
US National Committee, International Union of Pure and Applied Chemistry, 1978-1981
Editorial Board, Journal of College Science Teaching, 1976-1978
Editorial Board, Chemical and Engineering News, 1976-1978
Chairman, Division of Chemical Education, American Chemical Society, 1971
National Science Board, 1972-1978
Board of Publication, Journal of Chemical Education, 1959-1966, 1970-1973, Chairman, 1964-1965

Honors:
American Chemical Society Award in Chemical Education, 1982
James Flack Norris Award for Outstanding Achievement in Teaching of Chemistry, Northeastern Section of American Chemical Society, 1977
Manufacturing Chemists Association Award in College Chemistry Teaching, 1969
Petroleum Research Fund International Grant, American Chemical Society Petroleum Research Fund, 1959-1960
Sarah Berliner Fellowship, American Association of University Women, 1952-1953
Frank Forest Award, American Ceramic Society, 1949

STATEMENT OF DR. ANNA J. HARRISON, PRESIDENT, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. HARRISON. Thank you, Mr. Chairman.

My intent is to comment orally on one aspect of my written statement, and that aspect is the 1985 budget request as it affects all areas of science and engineering research. And in actual fact, I will only comment on one factor of that. So I am choosing deliberately to focus rather narrowly.

First a few words about the AAAS, because what I have to say should be viewed against that background. It has a membership of 135,000, plus or minus a little, and those individuals are involved in the process of investigation of physical, biological, behavioral, social, economic, and political phenomena. They also are involved in the investigation of how to solve problems and resolve issues that involve physical, biological, behavioral, social, economic, and political phenomena.

The AAAS is unique in that it is a multidisciplinary organization, and it therefore addresses issues of interest to scientific and engineering societies in general. There are some 282 affiliated engineering and scientific societies related to the AAAS.

We also provide the mechanism for communication amongst these professional societies, and we provide a forum to address many issues that are in common to the various professions, and particularly those that relate to the impact of science, engineering, and technology upon society.

If you look at the activities of the AAAS, you will find that there is a very strong commitment to the use of the capabilities of science, engineering, and technology to enhance the quality of life of this and succeeding generations. I might say that we view that not in the sense of a nationalistic focus but in terms of a world focus on the basis that quality of life cannot be defined by political lines.

You ought to also know that in order to have some basis of what position I am going to take that I am a physical chemist; I am a past president of the American Chemical Society, and a former member of the National Science Board.

Now, the comments that I will make relate to the table that is a part of my written statement, and it will help me a lot if you will open to that table. There are three pages of it. A large part of the table you have seen before, with some additional columns that have been added in.

As you know, the National Science Foundation has seven directorates, one of which is administration. That I will not be concerned with. Of the other six, I will only be concerned with four, and you will find information, reference to funding, for those four directorates on the first two pages.

Those four directorates are: Mathematical and physical sciences, engineering—those appearing on the first page—and on the second page, the other two, biological, behavioral and social sciences, and also astronomical, atmospheric, Earth, and ocean sciences.

Now, I shall refer to those four directorates as R&D directorates. That is approximately true. They are primarily focused toward research and development. There is some research involved in the other two directorates which I am not grouping in that, and there are a few things within these directorates that would not be really fundamentally or directly research and development, but it is a convenient way of looking at what otherwise is an extremely complex situation.

I will be concerned with only the two columns to the right hand of the page in each case. The other columns more to the left hand and the center of the table provide the numbers from which those last two columns are obtained. They are only there to give it a sort of sense of credibility, shall we say.

Now, the two columns at the extreme right-hand edge of the page deal with the percent of change of the requested 1985 budget with respect to 2 reference years. One is the current plan for 1984, and the other year is 1980; in other words, 5 years back.

At the moment, I would like for us to look at the column that gives the percent change from financial year 1984 to financial year 1985; in other words, one column in from the right of the page.

As you know, this budget is a robust budget with very substantial increases in level of funding with respect to 1984, and that is in fact what this table shows.

Of the four directorates, the lowest percentage increase is 12.6 percent for the biological, behavioral, and social sciences. You will find that number on the total line under the biological, behavioral, and social science directorate.

The largest increase is for engineering of 21.9 percent of the directorates, and then, of course, the other two falling in between.

Are you all with me all right on the tables I am talking about? OK. Otherwise, this sounds like nonsense; it may, anyway.

Now, if we look again within that same column, you will have the subactivities within each of the directorates. If you follow through those, you will find that the lowest increase, percentage increase, is 8.1 for the Arctic research programs, 8.2 for informational sciences and technology programs.

Those proposed increases are, of course, above a predicted level of inflation, and it is a positive picture all the way through.

Now, I would like to do the same sort of comparison but this time using the outside column of figures, which makes the comparison between the proposed 1985 with the actual for 1980, a 5-year period.

Again looking at the directorates over that 5-year period—and this has been reduced to constant dollars—the biological, behavioral, and social sciences have in fact decreased over that 5-year period by 1.2 percent. That is the only one of the directorates in which there has been a decrease. The highest increase is 39.2 percent for engineering.

Now, if you look within the subactivities over this 5-year period, you will find that the range is very high, from a decrease of 48.7 percent to an increase of 71.5 percent, a decrease over that 5-year period, the largest decrease, being for the social sciences, essentially a 50-percent decrease in the 5-year period.

The highest, the 71.5 percent, is for electrical, computer, and systems engineering. Are you with me all right? No problems on that? OK.

Now, I would like to raise with you one question, and that question is the adequacy in both magnitude and rate of growth of Federal support of R&D for biological, behavioral, social, economic, and political sciences.

The answer to that question is a value judgment. That is a responsibility of the surrogates of the public, those elected by the public or those appointed by those who are elected by the public. It is not my responsibility to answer that; it is not my prerogative to answer that, but I would be delighted to help you with the analysis.

Mr. **Walgren**. We would be delighted to have your guidance.

Dr. **Harrison**. Now, I would like to talk just a little bit about science and a little bit about engineering, and I am going to do it in a very simplistic way.

Science is a process of investigation of physical, chemical, biological, behavioral, social, economic, and political phenomena. It is a process of investigation. The legacy of those investigations is a body of scientific knowledge.

Engineering is the process of investigating how to solve problems, and using, in the process of this, physical, chemical, biological, possibly behavioral, social, economic, and political. But in actual fact, engineering as it has traditionally been used has only been the approach to investigating problems using physical and chemical phenomena. More recently, of course, we have become quite accustomed to medical engineering, bioengineering, genetic engineering, et cetera, which again is the approach of how to solve problems but using biological phenomena.

These processes of investigation, of how to solve problems, generate a body of knowledge. That knowledge is engineering knowledge and consists of a data base, an array of methodologies, and an array of concepts.

The scientific investigations, the investigations phenomena, which also generated a body of scientific knowledge, and there again they consist of a data base, an array of methodology, and an array of concepts.

The two are very similar, but they are different. The engineering has its own methodologies and it has its own creativity.

Now, I have tried this out on engineers—matter of fact, I learned it from engineers; I never dreamed this up myself—and they don't seem to be annoyed by it.

Now, the point that I want to discuss is this: in what way does knowledge, the total body of knowledge—scientific knowledge, engineering knowledge, and also a body of knowledge that is generated by technology, technological knowledge, which again is a data base, an array of methodologies, and an array of concepts—serve society. What value does that total body of knowledge serve society?

Only three aspects of that do we need to consider here. One is that body of knowledge serves as a basis for the further investigation. In other words, the body of knowledge makes it possible for us to get on with the business of science or engineering or technological innovation, for that matter, and create more knowledge.

This body of knowledge also serves as the basis of our perception, at least in part, of the environment of which we are a part—the physical, the chemical, the biological, the social, the economic and political environment.

That body of knowledge serves in part to provide us with a perception of ourselves and our relationships with others.

That body of knowledge also serves to support technology. This is what you hear most about, the support of technology. It is the support of technological innovation, the support for the production and development and the delivery of goods and services; and it is also the support for the effective utilization of those goods and services, and that is a point which sometimes gets left out—the effective utilization of the goods and services that we produce.

Now, I would like to make a few comments on the impact of technological change. The statement I am going to make cannot be proven, but I will talk about it after I have given it to you. Every technological change, whether it is by transfer or by innovation, and regardless of how great its positive impact on society, also has a negative impact.

For some 6 or 7 years, I have been making that statement in addresses, challenging the audience to cite specific examples for which it is not true, and as of today, I know of no example for which it is not true. Every technological change, regardless of how great its positive impact on society, also has a negative impact on society.

Now, there are some things that we need to consider about that, and part of it is that the benefits of a technological change and the burdens of a technological change may fall on different subsets of society. Unless we analyze in such a way that we know where those benefits go and those burdens go, we really do not know the impact on society.

The benefits and the burdens may fall in quite different timeframes. Obviously, the benefits tend to come rather early and the burdens to trail later, if there is a difference in timeframe; otherwise, we wouldn't have gotten into it in the first place.

It also means that in our analysis, our data has to be handled in such a way that we can follow successive time intervals in the impact of both a positive and negative sort.

The third characteristic is that the nature and magnitude of the benefits and the nature and magnitude of the burdens may be quite different. The sweet-bitter characteristic of technological change in fact has nothing to do with technology at all. It is a characteristic of change, any change, social, economic, or political, that it has a negative as well as a positive impact.

We are in the business of technological innovation, of bringing about change, and, consequently, we face into this more directly.

Now, I would like to talk just a little bit about societal issues. The ones, of course, as children that we first met were food, clothing, and shelter, but they include a variety of other things such as what do we do with our wastes; the problems having to do with abused children and international conflict. There are all kinds of social issues around the place.

So far as I know, all of the societal issues have to do with the quality of life. Included within the quality of life are such things as national defense and economic growth, but that is simply a part of the total question of the quality of life.

Economic indicators are, in general, inadequate for assessing quality of life. They are a substitute, but they are really a very poor substitute. We do not have established indicators for quality of life except to generally accept it; and particularly are economic indicators misleading if that information cannot be disaggregated in such a way that we can distinguish among subsets of society and in different timeframes, successive timeframes.

Now, I would like to return to the question initially: Is the Federal support for R&D for the biological, behavioral, social, economic, and political issues adequate?

In order to answer that, you would also have to inquire into what are the other sources of Federal support. All of us, of course, are quite familiar with the support of biological activities in the Department of Agriculture, NIH, et cetera. It is not so evident where other sources of support are for behavioral, social, economic, and political.

You have to go further than the NSF. The total NSF support of the Federal basic research effort is a little less than 17 percent. So we are only looking at a very small segment here.

I simply say to you that the question is yours.

Now, I would like to make one statement, however, as to why I am so concerned about it. I am concerned about it because I think that unless we address the rate of growth of the social, economic, and political sciences, we will in fact not be able to understand the impact of science and technology upon society.

I am extremely proud of the physical sciences. That is my turf. But I also have been very much conditioned by my experience with the American Chemical Society and what may be called public acceptability; that in fact we may be very limited in capitalizing on the technology that we can produce using physical phenomena.

Now, if you look at the four directorates we have here, the mathematics and physical sciences directorate obviously is dealing wifh mathematics and physical sciences. Engineering, if you look at the subactivities, is also dealing with those aspects of engineering that deal with mathematics and physical sciences, physical phenomena.

If you look at the Astronomical, Atmospheric, and Earth and Ocean Sciences, they, too, are largely physical sciences with which you are dealing there. There is some biology in the oceanography and in the Arctic research, but for the most part, this is physical.

I am very much concerned about this question of perception. If we are going to be involved in resolving societal issues such as international conflict, it is not merely a question of national defense; there is that very significant element of negotiation which requires, in order to do it effectively, that one understands the social, the political, and the economic structures of those nations with which one is dealing, what their priorities are, and what impact the proposals that one suggests will have on the social, economic, and political structures of those nations and particularly upon their priorities.

If you look at something such as waste disposal, you have the question not only of the technology, using the physical and the biological phenomena, but there is a whole host of social, economical, and political questions that have to be addressed.

Now, we do not use the term, but I have a feeling that in fact we practice what is equivalent to engineering using these other types of phenomena; and as we move further and further toward a service society and an information society, it becomes much more significant than it has ever been before.

That ends my statement at this point.

[The prepared statement of Dr. Harrison follows:]

Statement by

ANNA J. HARRISON

President

American Association for the Advancement of Science

on

The Fiscal Year 1985 NSF Budget Authorization Request

I am Anna Harrison, president of the American Association for the Advancement of Science. First, a few words about AAAS. AAAS has a membership of approximately 135 thousand. This encompasses a wide array of individuals professionally involved in the investigation of physical, chemical, biological, behavioral, social, political and economic phenomena and the use of physical, chemical, biological, behavioral, social, political and economic phenomena to solve problems and resolve issues.

The unique potential of AAAS is its capacity to facilitate communication among the great multiplicity of scientific, engineering and related professional societies, to provide mechanisms to address issues of concern to these organizations and to provide public forums to address issues which involve the relation of science, engineering and technology to society. The activities of AAAS reflect its strong commitment to the use of science, engineering and technology to enhance the quality of life of this and succeeding generations.

We have a vital interest in the level and the rate of growth of federal support for investigations in mathematics, science and engineering and for education in mathematics, science and engineering at all levels.

The $1.5 billion proposed FY 1985 NSF budget is very reassuring. In a period of alarming national deficits, this 14% increase over the $1.3 billion of the FY 1984 current plan demonstrates the commitment of the current administration to the support of mathematics, science and engineering research through the National Science Foundation. The overall increase in NSF's R&D budget is again one of the largest R&D increases among the federal agencies.

To assess the NSF budget, from the standpoint of AAAS, requires an inspection of both the magnitude and the rate of growth of proposed obligations by activity and subactivity. The attached table is essentially the budget summary table given on page 32 in the green booklet, National Science Foundation Budget Summary Fiscal Year 1985, with one column deleted and two columns added. The column deleted is the incremental difference between FY 1984 current plan and the FY 1985 proposed budget. The added columns are FY 1980 (actual) and the percent changes from FY 1980 to FY 1985 corrected for inflation. There have been a few corrections of minor magnitudes in some of the figures in the NSF Budget Summary FY 1985 table as published in the green booklet.

My focus for the moment will be upon the first four directorates. These four directorates account for $1.2 billion of the FY 1985 budget and I shall refer to these directorates as the four R&D directorates. Two other directorates will be considered separately.

The FY 1985 proposed budget for each of the four R&D directorates has a very significant increase compared to the FY 1984 current plan, ranging from 12.6% for Biological, Behavioral and Social Science to 21.6% for Engineering. All subactivities within the four directorates show significant real growth, ranging from 8.2% to 24.3% in current dollars. The pattern of increases for FY 1985 is very similar to that for FY 1984, although slightly less in magnitude.

An inspection of the subactivities of these four R&D directorates indicate that three of the four deal primarily, but not exclusively, with investigations in mathematics, investigations of physical and chemical phenomena, and investigations in the use of mathematics and physical phenomena in solving problems. These three directorates are: Mathematical and Physical Sciences, Engineering; and Astronomical, Atmospheric, Earth and Ocean Sciences, with a total proposed budget of $0.94 billion. NSF supported investigations of biological, behavioral, social, political and economic phenomena, and the use of biological, behavioral, social, political and economic phenomena in solving problems and resolving issues are primarily, but not entirely, grouped together in the fourth directorate, Biological, Behavioral, and Social Sciences with a proposed budget of $0.25 billion.

A somewhat different pattern of growth emerges if the proposed FY 1985 budget is compared with the FY 1980 (actual) budget. By directorates, the percent changes from FY 1980 to FY 1985 (corrected for inflation) range from a decrease of 1.2% for Biological, Behavioral and Social Sciences to an increase of 39.2% for Engineering. By subactivity, percent changes range from a decrease of $48.7% for Social and Economic Sciences to an increase of 71.5% for Electrical, Computer and Systems Engineering. For the five-year period, the funding of two other subactivities also decreased. The decreases are 2.2% for Behavioral and Neural Sciences and 14.2% for Information Science and Technology.

I raise the question of the adequacy of the national investment in the investigation of biological, behavioral, social, political and economic phenomena and the investigation of the use of biological, behavioral, social, political and economic phenomena in solving problems and resolving issues. This is a very fundamental question. The answer is a value judgment and can only be made for the nation by the public through the surrogates of the public — those elected by the public and those appointed by those elected.

To explore the question involves a consideration of the ways scientific and engineering investigations serve the public good. Science, the investigation of phenomena, generates a body of scientific knowledge consisting of a data base, an array of methodologies and an array of concepts. Engineering, the investigation of how to solve problems, generates a body of engineering knowledge consisting of a data base, an array of methodologies and an array of concepts. The combined body of knowledge serves society in at least three significant ways.

1) It enhances our capacities to carry on further investigations of phenomena and further investigations of how to solve problems.

2) It is in part the basis of our perception of our physical, biological, social, political and economic environment, in part the basis of our perception of ourselves and our relations with others and in part the basis of our perception of our capabilities to carry on further investigations and to solve problems. And,

3) it fosters technological innovation, supports technology (the production and delivery of goods and services) and supports the effective use of the products of technology.

Approximately three quarters of the proposed FY 1985 budget for the four R&D directorates is for the support of investigations in mathematics, investigations of physical and chemical phenomena and investigations of how to solve problems (engineering) using physical phenomena.

The scientific, engineering and technological community cannot solve societal issues. Only society can solve societal issues. Scientists and engineers can identify issues, assess the nature and magnitude of the issues, identify areas requiring further investigations, propose technological options, assess the probable positive impacts and the probable negative impacts of each option (including the option to do nothing) on society. Societal issues have to do with the quality of life and decisions having to do with the quality of life are prerogative of the public and the surrogates of the public. Once the decision is made to implement a particular option, scientists and engineers have a great deal to do with the implementation of that option.

I consider the selective use of technology to enhance the quality of life of this and succeeding generations to be one of one most significant societal issues. Concerns related to the quality of life include national defense and national economic growth but are in no sense limited to those two very significant issues.

Every technological change, brought about by either transfer or innovation, has a negative impact on society regardless of how great the positive impact of that technological change upon society. There is no direct proof for this statement. For some years I have challenged audiences to cite examples of technological change for which the statement is not true. I still know of no example for which it is not true. The subset of society that derives the benefits may not be the subset that bears the burdens. The time frame within which the benefits become evident may be quite different from the time frame within which the burdens become evident. The nature and magnitude of the benefits may be quite different from the nature and the magnitude of the burdens. The goal is, of course, to selectively use technology to enhance the quality of life and more equably disperse the benefits and burdens of technological change.

We have yet to develop generally accepted quality of life indicators and the practice of using economic indicators is at best a very inadequate substitute - particularly if the data base cannot be disaggregated to monitor identifiable subsets of society in successive time intervals.

The sweet/bitter consequence of technological change is not a unique characteristic of technological change. It is instead a characteristic of change - all social, political and economic change. The goal of technological transfer and technological innovation is change.

Traditionally, engineering has been the investigation of problem solving through the utilization of physical and chemical phenomena. The subactivities of the NSF FY 1985 budget of the Engineering Directorate encompass this type of engineering. Today, engineering also encompasses the investigation of problem solving utilizing biological phenomena and terms such as bioengineering and genetic engineering have become a part of our language.

Parallel approaches to the solution of problems and the resolution of societal issues involve and utilize behavioral, social, political and economic phenomena. Societal issues such as abused children are only very remotely related to physical phenomena and the resolution of such issues is not to be found in the utilization of physical phenomena. Even the resolution of issues, such as waste disposal, which do involve physical, chemical and biological phenomena are dependent upon the resolution of a host of behavioral, social economic and political problems as well as the development of technological options involving physical, chemical and biological phenomena. The approach to the resolution of international conflict through negotiation is highly dependent upon the knowledge and understanding of the social, economic and political structures and priorities of the nations involved and an understanding of the relation of proposed solutions to those structures and priorities.

To assess the adequacy of the federal support for basic research in the biological, behavioral and social sciences goes far beyond a consideration of the NSF budget. Under the proposed FY 1985 budget, NSF would support less than 17% of the total federal basic research effort. We are all familiar with the support of investigation of biological phenomena in departments such as Agriculture and Health and Human Services. Other sources of support for investigations of behavioral, social, political and economic phenomena are not as visible.

I am a physical chemist and am well aware of and very proud of our Nation's tremendous capabilities to investigate physical and chemical phenomena, to use physical and chemical phenomena to develop technological options and to use the data base, the methodologies and the concepts of the physical sciences and of engineering to investigate biological phenomena and to investigate extremely large and complex systems such as the oceans. The capacity of this Nation to plan and undoubtedly build and effectively use the long base line array of radio telescopes is an elegant display of past accomplishments and current capabilities. It is exactly this pride in the past and this confidence in our current capabilities that leads me to be so concerned that limited knowledge and understanding of behavioral, social, political and economic phenomena could inhibit the resolution of societal issues and the enhancement of the quality of life.

The AAAS Board recognizes the synergistic nature of science and engineering and also the growing unity of science and engineering, even though the disciplines of science and the disciplines of engineering are rapidly proliferating. The AAAS Board is in the process of taking to the AAAS Council a recommendation for a change in AAAS goals to recognize and facilitate the growing unity of science and engineering and the AAAS would support the investigation of mechanisms to bring science and engineering closer together in federal agencies.

The Scientific, Technological and International Directorate (STIA) is quite different in structure and foundation from the four R&D directorates. One of its more interesting features is that it coordinates a number of activities which are carried out by the R&D directorates and funded through the R&D directorates in the proposed FY 1985 budget to the extent of $60.7 million. These special activities include the NSF Small Business Innovation Research Program, the Indo-US Science and Technology Initiative, Research Opportunities for Women, Presidential Young Investigators Research Awards and Support for Predominantly Undergraduate Institutions. This approach assures the standards of excellence and processes of peer review characteristic of NSF R&D directorates. It is too early to assess the success of this approach. In principle, I find the approach attractive and suspect that the degree of success will be closely related to the quality of oversight within STIA and also the level of oversight of the NSF Director. It will require diligence to assure that these activities do not become diffused and possibly distorted or diverted by the R&D directorates.

Another subactivity of STIA is policy research and analysis. I believe that this should involve two types of research and I am not confident that it does. The two types of research are: 1) research on science policy as a discipline and 2) research and analysis as a basis of formulating agency or government policies dealing with science, technology and natural resources. Both types of research and analysis are important but they are different. I believe that it is important to recognize and maintain the difference. In the first case, the investigator is a student of science policy and presumably has no vested interest in the outcome of the analysis. In the second case, the investigator becomes a participant in the formation of policy dealing with science, technology and natural resources and may impose personal value judgment on the outcome of the analysis. There is ample evidence of research of the second kind. It is not clear how much support is given to investigations of the first type -

the research essential to the development of the discipline of science policy. The first type of research parallels the type of research essential to the development of the discipline of chemistry.

STIA also has the responsibility to conduct surveys and maintain the science resource data base. AAAS places a high value on the potential usefulness of this data base for research, including research to assess the entry of women, minorities and the physically handicapped into scientific and engineering careers and the movement of women, minorities and the physically handicapped up the career ladders of scientific and engineering professions. We recommend oversight to insure that the data base for scientific and engineering personnel can be disaggregated to yield this information.

The FY 1985 budget for the Science and Engineering Education Directorate is stated in terms of two subactivities, Graduate Research Fellowships and Precollege Science and Mathematics Education.

A modest increase in funding for fellowships provides for a modest increase in the number of fellowships and in the stipends of the fellowships. This well-established program remains intact.

The proposed FY 1985 budget is 22% lower than the funds made available under the FY 1984 current plan for precollege science and mathematics education.

I find this action to be absolutely astounding. Even assuming that Congress will intervene and increase the funding for precollege education, the Science and Engineering Education Directorate will have been denied the opportunity to design and to present a coherent program. The course taken by the Directorate seems to be the presentation of a very nebulous array of programs that far exceeds the level of funding made available in the proposed budget. There will undoubtedly be proposals and some meritorious proposals will be funded, but there will be no identifiable thrust by the National Science Foundation. We need leadership from the National Science Foundation in precollege education and in my opinion, we do not have it.

I serve on the Education Commission of the States Task Force on Education for Economic Growth and am well aware of the initiatives being taken in many of the states largely as a consequence of the leadership of the governors of those states. The progress being made is impressive. These initiatives for the most part address the environment within which education takes place - the number of required courses, pay for teachers, the availability of equipment, the length of the school day, the length of the school year, discipline, etc. They do not tend to address the nature of the educational experience itself. To address the nature of the educational experience in mathematics and science for all students at the precollege level is, to me, uniquely appropriate to the National Science Foundation. In the smorgasbord of programs mentioned in the supporting budget documents, there are opportunities to address the nature of the educational experience but there is no thrust. The value of the whole should exceed the value of the sum of the parts.

The place of the NSF in precollege education must be addressed by Congress during this session of Congress. The National Science Board (NSB) Commission on Pre-College education first met in July 1982; it transmitted its report to Congress, and to the NSB in September 1983.

For another year to go by without vigorous action will be negate the responsibility of Congress and the NSB.

The remainder of this statement will consist of brief comments on a variety of general issues.

International Activities. AAAS interests, goals and practices are entirely consistent with the National Science Board Statement on Science in the International Setting (September 1982) and it is not necessary to restate those principles here. (A copy of the Board statement is attached.) We urge a stable rate of growth in the support of programs consistent with the NSB statement. One of the AAAS activities is to serve as the secretariat for the Consortium of AAAS Affiliated Scientific Societies for International Programs. The Consortium provides a communication system for about 70 scientific and engineering societies with international programs.

Access to computer facilities and electronic information systems. AAAS recognizes the essential nature of ready access to appropriate computer facilities and to scientific and engineering information for all scientists and engineers in all scientific and engineering disciplines and we urge NSF to assist scientists and engineers to discover the potential of computer methodologies appropriate to their research and to facilitate access to computer facilities and information systems through networking and siting appropriate computers at strategic locations. In particular, we make the plea that scientists and engineers, in subdisciplines that have yet to embrace wholeheartedly computer methodologies, be involved in the strategic planning for the installation of computers and the development of networks.

We recognize that computer generations follow computer generations and that only long-term planning can insure the availability of the latest generation of computer systems. Access and utilization to these advanced computers and information systems is revolutionalizing the ways in which scientific and engineering investigations are carried out. This is an issue that goes far beyond the capabilities of any one agency to address in an adequate fashion for the nation. It calls for strategic thinking in terms of what are appropriate national actions — governmental and private — and how the support shall be provided.

Administrative Issues. (Personal comments) The scientific and engineering community was shaken by the circumstances under which some of the assistant directors at NSF were asked to leave in late 1982. At the time, I was assured that I would be reassured when the identity of the replacements became known. The sad fact is that five of the directorates discussed in this statement are still operating under the leadership of acting assistant directors. Equally troubling is that several of these acting assistant directors continue to fulfill as well the responsibilities of the positions they held before the appointment to an acting assistant director. This is not reassuring to the scientific and engineering community.

Second Comment. During the last years that I served on the National Science Board, I chaired the Program Committee of the Board. On the basis of that experience, I strongly support the recommendation of the Chairman of the National Science Board to amend the NSF Act to allow the Board to delegate the Director approval authority for grants that do not exceed $6 million in total or $1.5 million in any one year. Even in 1977 and 1978 the current maxima of $2 and $0.5 million excessively focused the attention of the Board on big science and it was essentially impossible to develop an in depth concept of the activities of NSF in the support of small science.

The NSF Budget Process. (Personal comment) I regret the pattern of events that pits a commitment to science and engineering education against a commitment to research in science and engineering. Many of us discover that we have met the enemy and it is us. We are committed to both. This conflict is accentuated by the frequently reoccurring pattern of a very low proposed budget for science and engineering education being raised by Congress without increasing the total NSF budget. The net result is "that funds are transferred from research to education." I understand the game that is being played but I wonder if those who play it understand how divisive it is to the scientific and engineering community. Research and education are synergistic and they should be perceived to be synergistic.

General Comment. (Personal comment) The NSF FY 1985 proposed budget is a strong budget and any criticisms that I have made and questions that I have raised are derived from my confidence that NSF is a vital foundation and that it is fully capable of providing an even higher level of leadership and service to the scientific and engineering community and to the Nation as a whole.

Table . R&D in the National Science Foundation
(budget authority in millions).

	FY 1980 Actual	FY 1983 Actual	FY 1984 Current Plan	FY 1985 Budget	% Change FY 1984-85	FY 1980-85 Constant $
MATHEMATICAL AND PHYSICAL SCIENCES						
Mathematical Sciences	$ 25.0	$ 34.8	$ 41.5	$ 50.5	+21.7%	+46.4%
Computer Research	18.4	29.3	33.9	39.3	+15.9%	+55.3%
Physics	63.4	89.2	105.9	121.8	+15.0%	+39.2%
Chemistry	51.5	67.6	80.0	92.1	+15.1%	+29.8%
Materials Research	68.7	81.1	97.5	113.0	+15.9%	+19.2%
International Awards	*	-1.5				
Total	227.0	300.5	358.8	416.7	+16.1%	+33.0%
ENGINEERING						
Electrical, Computer, and Systems Engineering	18.9	29.5	36.0	44.7	+24.2%	+71.5%
Chemical and Process Engineering	16.0	22.6	26.6	32.5	+22.2%	+47.1%
Civil and Environmental Engineering	27.9	30.5	33.8	39.8	+17.8%	+3.5%
Mechanical Engineering and Applied Mechanics	13.8	19.4	24.3	30.1	+23.9%	+59.6%
International Awards	*	-0.9				
Total	$ 76.6	$101.1	$120.7	$147.1	+21.9%	+39.2%

	FY 1980 Actual	FY 1983 Actual	FY 1984 Current Plan	FY 1985 Budget	% Change FY 1984-85	FY 1980-85 Constant $
BIOLOGICAL, BEHAVIORAL AND SOCIAL SCIENCES						
Physiology, Cellular and Molecular Biology	$ 72.1	87.3	$102.1	$116.4	+14.0%	+17.3%
Biotic Systems and Resources	36.8	46.0	53.4	59.9	+12.2%	+17.8%
Behavioral and Neural Sciences	31.4	34.0	38.5	42.2	+9.6%	-2.8%
Social and Economic Sciences	39.7	20.3	24.6	28.0	+13.8%	-48.7%
Information Science and Technology	5.6	5.5	6.1	6.6	+8.2%	-14.2%
International Awards	*	-1.9				
Total	185.7	191.2	224.7	253.1	+12.6%	-1.2%
ASTRONOMICAL, ATMOSPHERIC, EARTH AND OCEAN SCIENCES						
Astronomical Sciences	56.7	62.7	78.2	93.4	+19.4%	+19.5%
Atmospheric Sciences	63.3	75.5	89.3	98.6	+10.4%	+12.8%
Earth Sciences	26.0	34.9	41.5	48.6	+17.1%	+36.0%
Ocean Sciences	66.3	102.5	113.7	124.9	+9.9%	+36.7%
Arctic Research Program	5.8	6.2	7.4	8.0	+8.1%	+.7%
International Awards	*	-1.0				
Total	$218.1	$280.8	$330.1	$373.5	+13.1%	+24.2%

	FY 1980 Actual	FY 1983 Actual	FY 1984 Est.	FY 1985 Budget	% Change FY 1984-85	FY 1980-85 Constant $
SCIENTIFIC, TECHNOLOGICAL AND INTERNATIONAL AFFAIRS						
Industrial Science and Technological Innovation	$ 10.4	$ 14.5	$ 17.6	$ 23.4	+33.0%	+63.1%
International Cooperative Scientific Activities	13.7	4.6	5.5	5.5	0.0	-70.8%
Policy Research and Analysis	5.5	4.3	4.6	4.7	+2.2%	
Science Resources Studies	2.7	3.6	4.2	4.3	+2.4%	
Research Initiation and Improvement	12.9	11.8	8.9	9.0	+1.1%	
International Awards	*	+5.3				
All other programs	7.0					
Total	52.2	44.1	40.8	46.9	+15.0%	-34.8%
SCIENCE AND ENGINEERING EDUCATION						
Graduate			20.3	21.0	+3.4%	
Precollege			68.6	54.7	-20.2%	
Total			88.9	75.7	-14.8%	

STATEMENT ON SCIENCE IN THE INTERNATIONAL SETTING
AS ADOPTED BY THE NATIONAL SCIENCE BOARD
AT ITS 238TH MEETING ON SEPTEMBER 16-17, 1982

The United States is at a critical point in its international scientific relationships:

- American scientists no longer lead in every field of science and U.S. industry is significantly challenged in many areas of technology.
- The global nature of many scientific problems, the resolution of which may significantly influence the future well-being of U.S. society, requires increased international cooperation and a coherent approach for successful study.
- The increased scale and complexity of many modern scientific projects requires facilities and operations whose costs strongly suggest the utility of international coordination, sharing and, in some cases, cooperative funding.
- Foreign policy considerations play an increasingly important role in the conduct of international scientific activities.
- Science and technology are becoming increasingly interdependent, and the national security implications of technology transfer have led to increased discussion of the need for additional controls on the international scientific communication process itself.

In view of the importance of these issues and their potential impact on the overall health of U.S. science, the National Science Board has addressed the broad topic of "Science in the International Setting." This statement expresses the Board's present policy and consolidates and extends a number of past Board actions on this subject.

IMPORTANCE OF INTERNATIONAL SCIENTIFIC COOPERATION

Scientific interaction at the international level is an essential element in the continued vitality of science. Historically, the Nation has profited greatly from its positive stance of encouraging outstanding scientists from throughout the world to be aware of and participate in our scientific activities and encouraging U.S. scientists to travel and interact closely with scientific projects in other nations.

There are certain fields in which international cooperation and access are essential to the effective conduct of research because the scientific questions being addressed are inherently global in nature. Examples include research related to climatology, oceanography, space applications, health, population and resource studies, acid rain, carbon dioxide buildup and heating of the atmosphere. Many of these issues are of serious concern to the future well-being of our citizens, as well as to those of other nations. Many disciplines, such as plant sciences, anthropology, and the geophysical sciences, require access to scientific sites in foreign areas.

The cost, scale and complexity of scientific facilities in many disciplines, such as high energy physics and astronomy, provide strong incentives for nations to share in the planning, financing, and use of such facilities.

The value of international scientific cooperation is by no means limited to the use of large facilities. Individual scientists in specialized fields often find international collaborative efforts to be of signal importance in facilitating the advancement of their fields.

SCIENTIFIC COOPERATION WITH VARIOUS NATIONS

The objective of maintaining the vigor of the U.S. research effort requires a broad, world-wide program of cooperation with outstanding scientists in many nations.

Cooperation with the industrialized democracies, such as OECD members and our NATO allies, is clearly of great value to the economic well-being and industrial capability of our own Nation as well as theirs. These nations enjoy comparable levels of technical sophistication and the potential for sharing advanced, costly facilities. Since opportunities for interaction with these countries are readily available, the greatest latitude should be given to individual cooperation and exchanges independent of formal bilateral programs. However, the NSF should continue to participate in selected intergovernmental agreements that serve identifiable useful functions.

Developing countries, many of which have a corps of highly qualified scientists, also offer significant opportunities for scientific cooperation, including unique possibilities for access to scientifically important territories and environments. Moreover, international scientific cooperation may offer economic, diplomatic and other policy benefits going beyond the immediate needs and interests of science per se. With many of these countries, bilateral agreements, including the provision for support and maintenance of continuity, are required to ensure the success of collaborative scientific activities. Since direct contact between the involved scientists is essential to ensure the effectiveness of the programs, the U.S. should continue to encourage an emphasis in its bilateral agreements on such scientist-to-scientist cooperation.

There is also evidence of benefit for U.S. science from contacts with scientists from Communist countries. Opportunities for individual scientific cooperation, even in the presence of strained political relationships, keep open channels for communication and can lay foundations for enhanced cooperation should conditions become more propitious in the future. Exchanges with Communist countries should be conducted so that commensurate benefits flow to both sides.

The levels of scientific activity with these three classes of nations will vary in time as scientific opportunities change and in reflection of the evolution of our foreign relations. At any given time, these levels will reflect a balance between needs and opportunities for American science and the goals and requirements of foreign policy and national security.

The Board concludes that because the international dimension is intrinsic to the nature of scientific research and because of the Foundation's role in the support of the Nation's foreign policy, the Director of the Foundation must play a significant role, in collaboration with the Department of State and the Executive Office of the President, in the development and implementation of the international science policy of the United States.

The Board strongly supports the Director in that very important dimension of his responsibilities. So that the Board can take these policy considerations fully into account in its planning, the Board must keep abreast of international initiatives and U.S. foreign policy objectives that should be considered in formulating the Foundation's priorities and budget.

MODALITIES FOR FACILITATING INTERNATIONAL SCIENTIFIC COOPERATION

Agencies such as the NSF, as well as universities and nongovernmental professional scientific organizations, will each have unique and important contributions to make toward the success of cooperative international scientific activities. The Foundation, by virtue of its fundamental and broad-based scientific program, should take the initiative, in cooperation with the Department of State and other agencies as appropriate, to bring together potential international partners to accomplish the necessary planning and implementation for international sharing or collaboration in fundamental science and engineering research.

Under the auspices of the International Council of Scientific Unions, a number of multilateral scientific programs have been successfully carried out, often with the cooperation and assistance of intergovernmental organizations and member governments. The International Geophysical Year program (the 25th anniversary of which is being commemorated now) has offered a useful paradigm for subsequent efforts in the atmospheric, geophysical and ocean regimes. The Foundation should use such multilateral channels when attractive opportunities arise.

The role of the National Academy of Sciences (NAS, NAE, IOM) as a Congressionally chartered, yet private organization, has enabled it to relate to many nongovernmental institutions throughout the United States in cooperating with other countries. This is a source of strength of which the Foundation should take full advantage. The National Academy has an especially significant role to play in facilitating international scientific cooperation, both by virtue of serving as the U.S. representative in connection with various nongovernmental international scientific organizations, and through bonds of cooperation with similar academies in other countries.

INTERNATIONAL SCIENTIFIC COMMUNICATION

Maintenance of a strong technological position is central to our national security and to our economic and commercial vitality. Technology leadership depends on a creative and vigorous science and engineering base which, in turn, benefits greatly from an effective international exchange of scientific and engineering information. Opportunities for exchange of novel ideas and rapid assimilation of new research results provided by contacts and conferences have long been important to the progress of science. These exchanges have served the Nation well in terms of contributing to rapid advances in basic research, innovation, application of research results, and development of state-of-the-art technology.

Foreign students, teachers, and researchers working on American campuses are also an important resource, both for our universities and ultimately for our industry's success in foreign markets. As a result of the advanced state of development of the U.S. scientific enterprise, the U.S. has been particularly efficient in absorbing, understanding, and extending new ideas from all sources, foreign and domestic; and this in itself is becoming an increasingly vital component of the success of U.S. science and its contributions to technology and industrial strength.

Advances in scientific knowledge are usually incremental and interdependent. They are facilitated by knowledge of other scientists' successes and failures, and by the criticism of one's peers -- that is, by open discussion. Openness on the campuses of American colleges and universities is particularly central; for it is there that new research directions are frequently conceived, and there that the next generation of scientists is trained. Restrictions which diminish that openness are likely to have serious costs to science and, ultimately, to national security. Such costs should be carefully considered in all dimensions before implementing any actions that would compromise the traditional open environment that has served us so well in the past.

In those special instances where universities choose to undertake proprietary or classified work, they may have to accept constraints on communication.

CONCLUDING STATEMENT

The nature of science requires that its international dimension be considered an organic aspect of the scientific enterprise. This dimension must be actively provided for in all Foundation programs, from education and fellowships to the various disciplinary efforts in the natural sciences, social sciences, and engineering. Planning for new facilities and the setting of priorities for major scientific investigations and programs should be carried out with the full recognition of the priorities of other countries and in an environment which encourages complementarity or planned supplementation, cost sharing, and coherence of the various efforts of cooperating countries. National Science Foundation organization and management procedures should reflect these principles.

The Board will continue its analysis of the subject of "Science in the International Setting" in connection with the preparation of the Sixteenth Board Report of this same title.

Mr. WALGREN. Well, thank you very much, Dr. Harrison. You have struck chords that certainly a number of members on the committee have been feeling as we have seen some of the changes recommended initially by this administration, and as we have tried to evaluate where NSF measures out its effort and what it might leave behind.

Let's hear Dr. Rosenzweig's presentation and then come back to both of you for discussion among the members.

So, Dr. Rosenzweig, if you would proceed, please, we would appreciate it.

[A biological sketch of Dr. Rosenzweig follows:]

ROBERT M. ROSENZWEIG
President
Association of American Universities
One Dupont Circle, NW
Washington, DC

Education

B.A., 1952, University of Michigan
M.A., 1953, Yale University
Ph.D., 1956, Yale University, Political Science

Professional Experience

- 1953-55, Instructor, Political Science, Amherst College
- 1958-61, Special Assistant to the Commissioner, U.S. Office of Education
- 1962-2/1983, Stanford University
  - 1962-67, Associate Dean, Graduate Division
  - 1967-68, 1972-73, Director, Center for Research in International Studies
  - 1967-71, Associate Provost
  - 1971-74, Vice Provost & Adviser to the President
  - 1963-82, Lecturer in Political Science
  - 1974-2/83, Vice President for Public Affairs
- 2/1983-present, President, Association of American Universities

Publications

The Federal Interest in Higher Education, with Homer D. Babbidge, Jr., 1962.

Research Universities and Their Patrons, with Barbara Turlington, University of California Press, 1982.

"Faculty and Standards of Ethical Conduct" in Sidney Hook, et al., *The Ethics of Teaching and Scientific Research*, 1977.

"The Stanford University Medical Center and the Federal Government." A report for the Sloan Commission on Higher Education and Government, with Christopher Wilkes and Nancy Freedman, 1977.

Articles for various publications including: *The Amherst Alumni Review*, *Midwest Journal of Political Science*, *The Graduate Journal*, *Higher Education*, *Journal of Higher Education*, *Stanford Today*, *Educational Record*, *Stanford MD*, *Change* Magazine, *Los Angeles Times*, *AGB Report*, *Washington Post*.

Additional Offices Held

President, Association of Independent California Colleges and Universities, 1978-1980, Vice President, 1980-82

Personal

Born: August 27, 1931, Detroit, Michigan
Family: Wife, Adelle; daughter, Kathryn; son, David

STATEMENT OF DR. ROBERT M. ROSENZWEIG, PRESIDENT, ASSOCIATION OF AMERICAN UNIVERSITIES

Dr. ROSENZWEIG. Thank you, Mr. Chairman.

I am sure the chairman will understand, given my long association with Stanford University before coming here, if I say that when Mr. Sensenbrenner left the room earlier, the number of Stanford alumni on the dais was reduced by 50 percent, although Mr. Brown is close enough in his district to Palo Alto so that we are prepared to accept him as an honorary alumnus of the university.

In any case, Mr. Chairman, I am pleased to be here and appreciate the opportunity to appear before you this afternoon to comment on the programs of the National Science Foundation and related matters of science policy.

In the brief time I will take for oral remarks, I want to focus on four specific items. Each of them is covered in more detail in the statement I submitted for the record.

The four are: first, overall funding levels for the Foundation; second, the institutional base of research; third, standards for awarding research dollars; and, fourth, the proposal to amend the NSF Organic Act to enhance the status of engineering.

Let me turn first to funds for research, and if I am brief under this heading, Mr. Chairman, I hope that my brevity will not be misunderstood as a lack of enthusiasm.

The proposed budget is very heartening to us. It bespeaks a recognition of the importance of basic research to the Nation. And, as I shall explain shortly under another heading, it also reflects an awareness that research takes place in institutions that themselves must be strong if the work done in them is to be of high quality.

Given the size and complexity of a National Science Foundation budget these days, it is no trick at all to suggest how it might be improved in this way or that way. Indeed, in my written statement, I have made a few such suggestions.

If those few changes were made it would be a better budget as we see it, but in all candor I should say that if they are not made, it would still be a very good budget indeed.

Let me turn now to what I have called the institutional base of science.

It strikes me that we may be learning something in this country and that what we are learning may be about to make a difference.

I think we have learned from the experience of our older heavy industries, especially steel and autos, that it is possible to go for a long time without investing in the modernization of plant and equipment. What happens when you do that, though, is that while you continue producing, your product slowly becomes less good, more expensive, and less competitive. If you continue that way long enough, you can still be producing something but be effectively out of business.

Exactly the same is true of research. We pretty much stopped investing in the plant and equipment required for modern research in the late 1960's. At the same time, we cut back substantially on programs designed to attract the best young college graduates into research and teaching.

Now, earlier investments sustained the quality of the research product for a decade and more, but we were approaching—indeed, I believe we have reached—the point at which that is no longer possible. Scientific equipment in universities is too often obsolete. Research facilities are in need of renovation or replacement. And faculty are growing old together, more or less gracefully.

It is tremendously encouraging to find in this budget and in several other agency budgets tangible recognition of the need to repair the research instrumentation base of science in universities. More needs to be done, but NSF's previous efforts on equipment and this year's continuation of them are welcome signs that the problem has been seen and that there is a determination to do something about it.

My statement for the record, by the way, describes a study project on research instrumentation that three of our associations are carrying out for NSF and for several other agencies.

I will turn now to standards for the allocation of funds for science. I would say to start that from time to time it really is worthwhile to recognize our accomplishments, even as we also recognize how far short of our aspirations they may fall.

In that spirit, I want to say that one of the truly heroic and sustained acts of self-restraint has been that practiced by the Congress in resisting temptations to substitute political considerations for scientific judgments.

Now, no human institution is perfect, not even, I guess, the Congress of the United States, but the record in this area over a long period of time is really a very good one.

In contrast, the Russians have, on occasion, practiced a form of science based on politics, one deriving from ideology. It has produced a series of disasters that has crippled their national effort.

In the last year or so, I am sorry to say, there have been signs that a different form of science based on politics has been creeping into our system, this one based on constituency advantage. If unchecked, it will produce disasters for our national scientific effort.

The reason is easy to understand. There is simply no point in doing less than the best science of which we are capable, and we can only do that if the decisions about what to do and who should do it are based on the best scientific judgment that we can muster. To settle for less is to waste the taxpayers' money and to risk the damage that the modern world holds in store for scientifically and technologically backward nations.

If that seems too apocalyptic a judgment, then you may discount my concern by some fair amount, and I submit that my main point still stands.

In recognition of the dangers that lie along the road that leads away from the judgment of science by scientists, a number of national organizations have issued statements affirming their commitment to the established processes of peer review. They are attached to the statement I submitted for the record.

It is extremely pleasing to us that several similar statements have been put in the form of concurrent resolutions by members of the Science and Technology Committee. We urge the prompt passage of a strong resolution.

I will turn now to the question of NSF organization, and on that subject I will limit my comments to the proposal to amend the NSF Organic Act so as to put engineering on a footing equal to science in the structure of the Foundation.

There was a time—and I have to say it was not too long ago—when engineering was a poor relation at the Foundation. There was no engineering directorate, and funds for engineering research and education were far down the list of Foundation priorities.

Happily, that time has passed, and while there may still be disputes about how much is enough for any set of disciplines, the engineers have clearly demonstrated their ability to hold their own in the budgetary rough and tumble. The figures that Dr. Harrison described earlier show that quite strikingly.

That being so, to amend the act, which has surely served us well over the years, so as to earmark status and rank for one set of disciplines can only have the effect of stimulating others to seek the same privilege, if only for defensive purposes.

The idea seems to us unwise and unnecessary. It is the kind of proposal that has come forward time and again at the National Institutes of Health as one or another discipline or disease group seeks statutory recognition. We have consistently opposed such moves there, and for the same reasons we oppose this one.

I thank you, Mr. Chairman, and I will be pleased to answer your questions.

[The prepared statement of Dr. Rosenzweig follows:]

STATEMENT OF

DR. ROBERT M. ROSENZWEIG
PRESIDENT

THE ASSOCIATION OF AMERICAN UNIVERSITIES

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

IN BEHALF OF THE

ASSOCIATION OF AMERICAN UNIVERSITIES
NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES
AMERICAN COUNCIL ON EDUCATION
COUNCIL ON GOVERNMENTAL RELATIONS
ASSOCIATION OF GRADUATE SCHOOLS
COUNCIL OF GRADUATE SCHOOLS

FEBRUARY 28, 1984

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE,

MY NAME IS ROBERT ROSENZWEIG, AND I AM PRESIDENT OF THE ASSOCIATION OF AMERICAN UNIVERSITIES. THE FIFTY RESEARCH UNIVERSITIES THAT COMPRISE THE AMERICAN MEMBERSHIP OF THE AAU INCLUDE ALMOST ALL OF THOSE INSTITUTIONS RANKED BY NSF AMONG THE TOP THIRD OF RESEARCH UNIVERSITIES IN TERMS OF FEDERAL RESEARCH AND DEVELOPMENTS OBLIGATIONS RECEIVED BY OUR UNIVERSITIES AND COLLEGES. THEREFORE THEY ARE THE UNIVERSITIES MOST CLOSELY INVOLVED WITH THE BASIC SCIENCE AND RELATED GRADUATE EDUCATION PROGRAMS OF THE NATIONAL SCIENCE FOUNDATION.

YOU HAVE ASKED ME TO PRESENT OUR VIEWS ON THE FY 1985 AUTHORIZATION REQUEST OF THE NSF. I AM PLEASED TO HAVE THIS OPPORTUNITY NOT ONLY TO ADDRESS THE NSF BUDGET REQUEST FOR NEXT YEAR BUT ALSO TO REPORT TO YOU SOME OF OUR CURRENT ACTIVITIES ON ISSUES CLOSELY RELATED TO THE FOUNDATION'S BUDGET PROPOSALS. MY COMMENTS ARE OFFERED ON BEHALF OF THE AAU AND SEVERAL OTHER LEADING HIGHER EDUCATION ASSOCIATIONS. TOGETHER THEY SHARE WITH THE AAU A PRIMARY CONCERN FOR THE HEALTH OF OUR RESEARCH-INTENSIVE UNIVERSITIES.

FY 1985 NSF BUDGET

TURNING TO THE BUDGET, WE ARE PLEASED TO BE ABLE TO SAY THAT WE ARE IN FULL SUPPORT OF THE ADMINISTRATION'S FY 1985 BUDGET FOR THE FOUNDATION. IT IS, WE BELIEVE, A SOUND INVESTMENT PLAN, ONE WHICH IF APPROVED AND FUNDED, WILL HELP TO BRING AN IMPORTANT ADDED MEASURE OF BALANCE AND STABILITY TO UNIVERSITY RESEARCH PROGRAMS. WE HOPE THAT THIS COMMITTEE WILL FULLY AND ENTHUSIASTICALLY SUPPORT NSF'S INVESTMENT PROPOSALS FOR RESEARCH IN BASIC SCIENCE, FUNDAMENTAL ENGINEERING, THE SOCIAL, ECONOMIC, AND BEHAVIORAL SCIENCES, AND FOR GRADUATE EDUCATION, AND UPGRADING RESEARCH INSTRUMENTATION IN NSF-FUNDED LABORATORIES. WE ALSO URGE YOUR SUPPORT FOR THE PROPOSED INTERDISCIPLINARY ENGINEERING CENTERS AND FOR THE IMPORTANT INITIATIVES TO IMPROVE ACCESS FOR UNIVERSITY RESEARCHERS TO ADVANCED SCIENTIFIC COMPUTERS. AS OTHER WITNESSES ALREADY HAVE STRESSED IN THEIR STATEMENTS, THESE INITIATIVES ARE URGENTLY NEEDED. THEY WILL ENHANCE RECENT EFFORTS TO ENSURE THE FUTURE VITALITY OF OUR SCIENTIFIC ACTIVITIES.

THE NEW PRESIDENTIAL YOUNG INVESTIGATOR AWARDS PROGRAM WILL ENTER ITS SECOND YEAR IN FY 1985. JUST LAST WEEK THE FIRST 200 AWARDS WERE ANNOUNCED. PERHAPS IT IS A MEASURE OF THE QUALITY AND SIGNIFICANCE OF AAU MEMBER INSTITUTIONS TO NOTE THAT 145 OF THE FIRST 200 AWARDS WERE MADE TO YOUNG RESEARCHERS BEGINNING THEIR CAREERS IN AAU MEMBER UNIVERSITIES. IT ALSO IS INTERESTING AND HEARTENING TO NOTE THAT MORE THAN 20 OF THE FIRST 200 AWARDS WENT TO YOUNG WOMEN. WE HOPE THAT THIS IMPORTANT PROGRAM WILL CONTINUE ALONG THE PATH TOWARD THE 1,000 AWARDS PLANNED FOR FY 1988. IT WOULD BE EXTREMELY DAMAGING TO THE CAREERS OF THESE YOUNG SCIENTISTS AND ENGINEERS IF THE STABILITY PROMISED BY THE PROGRAM WERE IN ANY WAY DISRUPTED BY ANY EVENTS THAT MIGHT

INTERVENE DURING THE 5-YEAR CYCLE OF EACH AWARD.

WE WOULD URGE, HOWEVER, THAT THE FOUNDATION MONITOR THE PROGRAM CAREFULLY TO ENSURE THAT THE PRICE FOR PROGRESS IN SUPPORTING YOUNG FACULTY IS NOT A LOSS OF SUPPORT FOR ESTABLISHED, PROVEN RESEARCHERS. SOME ARE CONCERNED THAT COMPETITIVE FUNDING FOR ESTABLISHED INVESTIGATORS MAY BE REDUCED IN ORDER TO PROVIDE SUPPORT FOR THE YOUNG INVESTIGATORS. OF COURSE, THIS WOULD BE COUNTER PRODUCTIVE AND DESTABILIZING. WE ARE CONFIDENT THAT THE FOUNDATION WILL TAKE THE STEPS NECESSARY TO ENSURE THAT SUCH UNINTENDED CONSEQUENCES ARE AVOIDED.

PEER REVIEW

THE FUTURE RETURN ON ALL OF THESE ESSENTIAL INVESTMENTS, OF COURSE, WILL BE DETERMINED IN LARGE PART BY THE SOUNDNESS OF THE DECISIONS THAT THE CONGRESS AND THE FOUNDATION MAKE IN THE AWARD OF THE FUNDS. THIS IS PARTICULARLY TRUE OF THE NEW PRIORITY PROGRAMS NOW BEING STARTED. THE PROPOSED NEW ENGINEERING CENTERS AND THE HIGH-PRIORITY PROGRAM DESIGNED TO IMPROVE ACCESS TO SUPERCOMPUTER FACILITIES WILL BE THE OBJECTS OF INTENSE INTEREST AND COMPETITION AMONG POTENTIAL HOST INSTITUTIONS. THAT IS AS IT SHOULD BE. THE FUNDS OUGHT TO BE AWARDED ON THE BASIS OF SCIENTIFIC MERIT IN OPEN COMPETITION AMONG ALL INTERESTED AND QUALIFIED PARTIES. FINAL JUDGMENTS OUGHT TO BE FORMED IN AN OBJECTIVE AND INFORMED MANNER, FREE FROM ANY ACTIONS BY PARTICULAR INDIVIDUALS OR INSTITUTIONS THAT COULD SERVE TO MAKE THE AWARD OF SUCH FUNDS A MATTER OF POLITICAL INFLUENCE RATHER THAN THE QUALITY OF THE WORK TO BE DONE AND THE CAPACITY OF COMPETING APPLICANTS TO CARRY OUT THE WORK AT THE HIGHEST LEVEL.

RECENTLY THE ASSOCIATION OF AMERICAN UNIVERSITIES, THE AMERICAN COUNCIL ON EDUCATION, THE NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES, AND THE COUNCIL OF GRADUATE SCHOOLS JOINED OTHERS IN ADDRESSING THE IMPORTANCE OF PROTECTING AND RELYING UPON THE ESTABLISHED PROCESSES OF INFORMED PEER REVIEW IN THE AWARD OF FUNDS FOR RESEARCH AND RESEARCH-RELATED PURPOSES. THE STATEMENTS RECENTLY ADOPTED BY THESE ASSOCIATIONS ARE ATTACHED TO MY STATEMENT (ATTACHMENT B).

WE ARE PLEASED TO NOTE THAT THIS CONCERN HAS GAINED THE ATTENTION OF THE CHAIRMAN AND MEMBERS OF THIS COMMITTEE. CHAIRMAN FUQUA, MR. SENSENBRENNER AND OTHERS HAVE INTRODUCED RESOLUTIONS AFFIRMING THE IMPORTANCE OF MERIT AND PEER REVIEW IN THE AWARD OF FEDERAL RESEARCH FUNDS. WE APPRECIATE THE COMMITTEE'S LEADERSHIP IN HELPING TO ENSURE THAT THESE ENDURING PRINCIPLES ARE NOT SACRIFICED TO SHORT-TERM EXPEDIENCY IN RESPONSE TO PRESSING INSTITUTIONAL ECONOMICS. WE HOPE ALL THE MEMBERS OF THIS COMMITTEE AND THE HOUSE WILL QUICKLY AND ENTHUSIASTICALLY SUPPORT THESE RESOLUTIONS.

GRADUATE EDUCATION

TURNING TO THE SUBJECT OF GRADUATE EDUCATION IN THE SCIENCES AND ENGINEERING, WE ARE PLEASED TO NOTE THAT THE NSF'S BUDGET CALLS FOR THREE IMPORTANT ADJUSTMENTS TO FOUNDATION POLICY. FIRST, THE BUDGET PROVIDES FOR ANOTHER SMALL INCREASE IN THE STIPEND AWARDED TO GRADUATE STUDENTS WHO SUCCESSFULLY COMPETE FOR THREE-YEAR PREDOCTORAL FELLOWSHIPS. FOR THE BETTER PART OF A DECADE THE STIPEND WAS UNCHANGED AND ERODED BY INFLATION. BUT FOR EACH OF THE PAST FEW YEARS THE FOUNDATION HAS TAKEN STEPS TO BRING THE STIPEND MORE INTO LINE WITH THE CURRENT MARKETPLACE FOR THE MOST TALENTED GRADUATES OF OUR UNDERGRADUATE ENGINEERING AND SCIENCE PROGRAMS. THE NSF PROPOSES TO INCREASE THE STIPEND BY $900 TO A LEVEL OF $9,000. AS WELCOME AS THIS CHANGE IS, WE MUST POINT OUT THAT THE STIPEND REMAINS SUBSTANTIALLY BELOW THE NEEDED LEVEL. THE DEPARTMENT OF DEFENSE, FOR INSTANCE, TWO YEARS AGO INITIATED A SMALL, MERIT-BASED, PORTABLE, GRADUATE FELLOWSHIP PROGRAM TARGETED ON SPECIFIC FIELDS OF INTEREST TO THE DEPARTMENT. THAT PROGRAM IS SMALL BY COMPARISON TO THE FOUNDATION'S. ONLY ABOUT 80 FELLOWSHIPS HAVE BEEN AWARDED; THE THIRD CLASS OF ABOUT 40 AWARDS WILL BE AWARDED SHORTLY. THE DOD PROGRAM HAS BEEN CAREFULLY DESIGNED TO RECOGNIZE THE TREMENDOUS MARKET PRESSURES NOW BROUGHT TO BEAR ON YOUNG POTENTIAL SCIENTISTS AND ENGINEERS. IN SEPTEMBER 1984 THE DOD PROGRAM WILL PROVIDE TO FIRST-YEAR STUDENTS STIPENDS OF $13,000 AND FULL TUITION TO THE INSTITUTION OF THE STUDENT'S CHOICE, PLUS AN AWARD OF $2,000 TO THE HOST DEPARTMENT TO BE USED TO STRENGTHEN GRADUATE RESEARCH. BY COMPARISON, THE NSF GRADUATE FELLOWSHIP PROGRAM PROVIDES ONLY A COST-OF-EDUCATION ALLOWANCE TO THE HOST INSTITUTIONS OF JUST $4,900, A FUNDING LEVEL ESSENTIALLY UNCHANGED FOR ALMOST A DECADE AND WOEFULLY INADEQUATE TO MEET THE COSTS OF A QUALITY GRADUATE PROGRAM IN THE SCIENCES AND ENGINEERING. THE NSF PROGRAM ALSO LACKS THE $2,000 GRADUATE RESEARCH AWARD TO THE DEPARTMENT PROVIDED BY THE EXCELLENT DOD PROGRAM.

WE HOPE THE COMMITTEE WILL CAREFULLY EXAMINE THE NSF'S PROPOSAL FOR THE GRADUATE FELLOWSHIP PROGRAM AND TAKE THE STEPS NECESSARY TO BRING IT INTO LINE WITH THE POLICY BEING FOLLOWED BY THE DOD. WE ESTIMATE THAT AN ADDITIONAL INVESTMENT OF $4.9 MILLION WOULD ALLOW THE FOUNDATION TO BEGIN TO PHASE IN A MORE APPROPRIATE FELLOWSHIP STRUCTURE BY INCREASING THE STIPEND TO THE LEVEL OF THE FIRST-YEAR DOD AWARDS AND INCREASE TO $10,000 THE COST-OF-EDUCATION ALLOWANCE FOR RECIPIENTS OF NEW AWARDS. OF COURSE, IT ALSO WOULD BE EQUITABLE TO ADJUST TO THE DOD LEVELS THE STIPENDS OF SECOND- AND THIRD-YEAR FELLOWS WHO ENTERED THE PROGRAM IN PRIOR YEARS. WE ASK THAT THE COMMITTEE CONSIDER STRENGTHENING THE FOUNDATION'S REQUEST BY AUTHORIZING AT LEAST AN ADDITIONAL $4.9 MILLION TO STRENGTHEN THE GRADUATE FELLOWSHIP PROGRAM. WE ALSO URGE YOUR SUPPORT FOR THE STEPS PROPOSED TO BRING TO MORE THAN 11,600 THE NUMBER OF GRADUATE RESEARCH ASSISTANTS SUPPORTED ON NSF RESEARCH PROJECTS AND TO INCREASE BY 200 THE NUMBER OF POSTDOCTORAL RESEARCHERS SUPPORTED. THE BUDGET REQUESTS THAT 3,500 POSTDOCS BE FUNDED NEXT YEAR. WE SUPPORT THAT PROPOSAL.

UNDERGRADUATE EDUCATION

OUR RESEARCH UNIVERSITIES ARE ALSO DEEPLY INVOLVED WITH AND CONCERNED ABOUT THE STATUS OF UNDERGRADUATE SCIENCE, ENGINEERING AND TECHNOLOGY PROGRAMS. ATTENTION MUST BE PAID TO THE NEEDS TO RENEW UNDERGRADUATE CURRICULA AND TO EXPAND RESEARCH OPPORTUNITIES FOR FACULTY AND STUDENTS IN UNDERGRADUATE SETTINGS. WE ARE PLEASED TO NOTE, THEREFORE, THAT THE FOUNDATION PROPOSES A SIGNIFICANT EXPANSION OF ITS PROGRAM OF RESEARCH AT PREDOMINATELY UNDERGRADUATE INSTITUTIONS. MANY OF THE STUDENTS WHO RECEIVE THEIR UNDERGRADUATE TRAINING IN THE LABORATORIES OF THESE INSTITUTIONS BECOME THE TALENTED GRADUATE STUDENTS IN THE LABORATORIES OF OUR LEADING RESEARCH INSTITUTIONS. WE HOPE THAT THE COMMITTEE WILL FULLY SUPPORT THIS INITIATIVE AND ALSO CONSIDER WAYS TO REBUILD WITHIN THE FOUNDATION A FOCUS ON THE NEED TO MODERNIZE UNDERGRADUATE CURRICULA IN SCIENCE AND ENGINEERING.

THE FOUNDATION PRESENTLY IS NOT PLAYING THE IMPORTANT LEADERSHIP ROLE APPROPRIATE TO IT IN THE UNDERGRADUATE ARENA. AS THE COMMITTEE CONSIDERS THESE QUESTIONS, WE DO HOPE THAT YOU WILL RESIST THE TEMPTATION TO ADDRESS THESE NEEDS BY A MERE REALLOCATION OF FUNDS FROM THE ONGOING RESEARCH PROGRAMS. WE BELIEVE BOTH THE RESEARCH AND EDUCATION NEEDS OF UNIVERSITIES AND COLLEGES MUST BE ADDRESSED ON THEIR MERITS AND NOT BE PITTED ONE AGAINST THE OTHER. OUR RESEARCH AND INSTRUCTIONAL SYSTEMS ARE INTERDEPENDENT AND INTERRELATED. THEY OUGHT TO BE FUNDED WITH AN EYE TOWARD MUTUALLY REINFORCING THEIR EFFECTIVENESS, NOT WEAKENING ONE OR THE OTHER IN A SEARCH FOR MUTUALLY UNSATISFACTORY SOLUTIONS.

RESEARCH INSTRUMENTATION

THE BUDGET REQUEST CONTINUES THE ESSENTIAL EFFORT TO UPGRADE UNIVERSITY RESEARCH INSTRUMENTATION AND EQUIPMENT. THIS IS AN IMPORTANT AREA, WHICH WE HAVE DISCUSSED WITH THE COMMITTEE ON SEVERAL PREVIOUS OCCASIONS. OF COURSE, WE FULLY SUPPORT THE FOUNDATION'S CONTINUING COMMITMENT TO THE INSTRUMENTATION INITIATIVE.

I SHOULD LIKE TO TAKE THIS OPPORTUNITY TO TELL YOU ABOUT A NEW PROJECT, NOW BEING UNDERTAKEN BY THREE HIGHER EDUCATION ASSOCIATIONS WITH THE SUPPORT OF NSF AND SEVERAL OTHER AGENCIES, TO EXPLORE ALTERNATIVE SOLUTIONS TO THE EQUIPMENT PROBLEM. THE PROJECT IS SEEKING TO IDENTIFY AND TO EVALUATE NEW APPROACHES TO ACQUIRING, MANAGING, AND USING EQUIPMENT AND TO INFORM THE UNIVERSITY COMMUNITY AND OTHERS OF THE RESULTS OF THESE EVALUATIONS. IT IS A JOINT UNDERTAKING OF THE AAU, THE NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES (NASULGC), AND THE COUNCIL ON GOVERNMENTAL RELATIONS (COGR). THE PROJECT IS BEING SUPPORTED JOINTLY BY THE NATIONAL SCIENCE FOUNDATION, NIH, DOD, DOE, USDA, AND NASA. THE RESEARCH CORPORATION ALSO HAS MADE A CONTRIBUTION. THE EFFORT IS BEING CARRIED OUT UNDER THE GUIDANCE OF AN EIGHT-MEMBER STEERING COMMITTEE DRAWN FROM UNIVERSITIES, INDUSTRY AND THE NATIONAL LABORATORIES. A LIST OF STEERING COMMITTEE MEMBERS IS ATTACHED (ATTACHMENT A).

THE PROJECT GROWS OUT OF A 1980 AAU REPORT NSF TITLED THE RESEARCH INSTRUMENTATION NEEDS OF UNIVERSITIES. THAT REPORT DOCUMENTED THE DIMENSIONS OF THE EQUIPMENT PROBLEM IN 15 LEADING UNIVERSITIES BY COMPARING THEIR RESEARCH EQUIPMENT HOLDINGS WITH THE EQUIPMENT USED IN A NUMBER OF LEADING COMMERCIAL LABORATORIES AND MAJOR NATIONAL LABORATORIES. AS SHOWN ON THE ATTACHED GRAPH (ATTACHMENT E), THE MEDIAN AGE OF THE EQUIPMENT IN THE UNIVERSITIES WAS FOUND TO BE THICE THAT OF EQUIPMENT IN THE COMMERCIAL LABORATORIES. BECAUSE THE REPORT WAS PRESENTED TO THE COMMITTEE BY THE ASSOCIATIONS IN EARLIER TESTIMONY, I WILL NOT DISCUSS IT FURTHER. THE EXECUTIVE SUMMARY OF THE REPORT IS ATTACHED TO MY STATEMENT (ATTACHMENT C). THE COMPLETE REPORT HAS BEEN PROVIDED TO THE STAFF OF THE COMMITTEE.

AS NEW INVESTMENTS IN RESEARCH EQUIPMENT ARE MADE BY NSF AND BY OTHER AGENCIES, WE ALSO MUST EXPLORE FOR NEW APPROACHES TO HELP ENSURE THAT OUR INVESTMENTS YIELD THE MAXIMUM SCIENTIFIC AND TECHNOLOGICAL RETURN.

RECOGNIZING THIS FACT, NSF ASKED AAU, NASULGC, AND COGR TO CONVENE AN AD HOC PLANNING COMMITTEE TO CONSIDER WHETHER A SPECIAL EFFORT WAS NEEDED TO EXPLORE WAYS TO IMPROVE THE ACQUISITION, MANAGEMENT, OPERATION, AND MAINTENANCE OF EQUIPMENT. THE GROUP IDENTIFIED THE FOLLOWING QUESTIONS:

1. DOES SO-CALLED DEBT OR CREATIVE FINANCING HOLD SIGNIFICANT UNTAPPED POTENTIAL FOR UNIVERSITIES AS A MEANS OF FINANCING NEW RESEARCH EQUIPMENT?
2. WHAT MORE CAN UNIVERSITIES DO TO IMPROVE THE WAY THEY ACQUIRE, MANAGE, AND USE RESEARCH EQUIPMENT?
3. CAN INNOVATIONS MADE BY GOVERNMENT AND COMMERCIAL LABORATORIES BE IDENTIFIED AND ADAPTED FOR USE BY UNIVERSITIES?
4. ARE THERE REGULATORY AND POLICY BARRIERS IN UNIVERSITIES OR THE STATES THAT CAN BE IDENTIFIED AND STEPS THAT CAN BE TAKEN TO REMOVE OR REDUCE THEM?
5. CAN PRESENT TAX INCENTIVES FOR THE DONATION OF RESEARCH EQUIPMENT BE IMPROVED TO INCREASE SUPPORT FROM INDUSTRY?
6. ARE THERE CHANGES THAT OUGHT TO BE MADE IN FEDERAL REGULATIONS THAT WOULD EASE THE SITUATION?
7. ARE THERE ALTERNATIVE METHODS OF DIRECT FEDERAL FUNDING THAT WOULD YIELD A BETTER RETURN ON FEDERAL INVESTMENT?

PHASE I

THE PROJECT BEGAN LAST NOVEMBER. IT IS SCHEDULED TO BE COMPLETED IN FEBRUARY 1985. THE WORK IS PLANNED IN THREE PHASES. DURING PHASE I ANALYSES WILL BE CONDUCTED IN SIX AREAS:

1. THE FIRST IS THE ROLE OF DEBT FINANCING OF RESEARCH EQUIPMENT IN SOUND UNIVERSITY FINANCIAL PRACTICE. CONSIDERABLE ATTENTION IS BEING PAID IN SOME PARTS OF THE RESEARCH COMMUNITY TO DEVELOPING NEW, CREATIVE MODES OF FINANCING THE ACQUISITION OF UNIVERSITY RESEARCH EQUIPMENT. THE POTENTIAL USEFULNESS OF SUCH APPROACHES IS BEING DEBATED INTENSELY, BUT THE TECHNIQUES THEMSELVES OFTEN ARE NOT WELL UNDERSTOOD, AND EXPERIENCE IN THEIR USE VARIES CONSIDERABLY.

   THIS ANALYSIS WILL IDENTIFY THE VARIOUS METHODS OF DEBT FINANCING. IT WILL ASSESS THE DESIRABILITY OF ENCOURAGING DEEPER INVOLVEMENT BY UNIVERSITIES IN THEIR USE, GIVE THE PROS AND CONS OF DIFFERENT FINANCING APPROACHES, AND PROVIDE EXAMPLES OF WHAT HAS WORKED, WHERE THESE TECHNIQUES HAVE WORKED AND WHY. THE ANALYSIS ALSO WILL OFFER SUGGESTIONS TO HELP INSTITUTIONS EVALUATE THE APPROPRIATENESS OF THESE APPROACHES IN THE LIGHT OF THEIR PARTICULAR CIRCUMSTANCES.

2. THE PROCUREMENT, MANAGEMENT, AND USE OF RESEARCH EQUIPMENT IS THE SUBJECT OF THE SECOND ANALYSIS.

   OPPORTUNITIES TO STRENGTHEN THE ORGANIZATION AND MANAGEMENT OF UNIVERSITY LABORATORIES AND SUPPORTING SERVICES WILL BE IDENTIFIED AND ASSESSED BY THE SECOND ANALYSIS. PARTICULAR ATTENTION WILL BE PAID TO NEW METHODS OF SHARING EQUIPMENT AMONG DEPARTMENTS AND UNIVERSITIES. THIS ANALYSIS WILL IDENTIFY BARRIERS TO SHARING INHERENT IN THE NATURE OF UNIVERSITY RESEARCH AND WILL CONSIDER POSSIBLE WAYS TO LOWER SUCH BARRIERS. RECENT EXPERIENCE IN USING ADVANCED TECHNOLOGY TO PROVIDE REMOTE ACCESS TO HIGH COST EQUIPMENT WILL ALSO BE EXAMINED. FINALLY, THE MANAGEMENT PRACTICES OF SELECTED COMMERCIAL AND GOVERNMENT LABORATORIES WILL BE REVIEWED TO SEEK APPROACHES THAT MIGHT BE ADAPTED TO THE UNIVERSITY SETTING.

3. THE THIRD ANALYSIS WILL ASSESS TAX INCENTIVES FOR THE DONATION OF EQUIPMENT AND SUGGEST WAYS TO INCREASE SUPPORT FROM THE PRIVATE SECTOR.

   THE ECONOMIC RECOVERY TAX ACT OF 1981 PROVIDED NEW INCENTIVES DESIGNED TO STIMULATE DONATIONS OF EQUIPMENT TO UNIVERSITIES BY INDUSTRY. EXPERIENCE TO DATE SEEMS TO INDICATE THAT THIS PROVISION IS HAVING A SIGNIFICANT AND BENEFICIAL IMPACT ON THE PROBLEM. THIS ANALYSIS WILL EVALUATE THE EXPERIENCE TO DATE AND ASSESS OPPORTUNITIES TO STRENGTHEN FURTHER THIS NEW INCENTIVE TO CORPORATE SUPPORT.

4. REDUCTION OF REGULATORY AND POLICY BARRIERS IN STATES AND UNIVERSITIES IS THE SUBJECT OF THE FOURTH ANALYSIS.

   A SELECTED NUMBER OF STATE GOVERNMENTS AND UNIVERSITIES WILL BE SURVEYED TO DETERMINE WHETHER THERE ARE POLICY AND

REGULATORY BARRIERS TO IMPROVED ACQUISITION, MANAGEMENT, AND USE OF RESEARCH EQUIPMENT. PARTICULAR ATTENTION WILL BE GIVEN TO PROVISIONS IN STATE CONSTITUTIONS AND LAWS WHICH MAY RESTRICT UNIVERSITY EFFORTS TO IMPROVE THEIR RESEARCH LABORATORIES. SOME STATES, FOR EXAMPLE, HAVE LAWS THAT INHIBIT GREATER USE OF CREATIVE FINANCING TECHNIQUES BY UNIVERSITIES. THIS IS A VERY COMPLEX AND DIFFICULT ARENA. BUT WE DO HOPE TO IDENTIFY SUCH BARRIERS AND TO FORMULATE PROPOSALS FOR IMPROVEMENTS OR CHANGES THAT MIGHT BE CONSIDERED BY STATE GOVERNMENTS AND THEIR PUBLIC UNIVERSITIES.

5. IN THE FIFTH ANALYSIS FEDERAL REGULATIONS GOVERNING THE ACQUISITION, MANAGEMENT, AND USE OF EQUIPMENT WILL BE REVIEWED.

RECOMMENDATIONS WILL BE MADE FOR CHANGES TO CURRENT REGULATIONS THAT WOULD FACILITATE EQUIPMENT ACQUISITION, ACHIEVE MANAGEMENT IMPROVEMENTS, AND EASE BURDENSOME REPORTING REQUIREMENTS.

6. THE SUBJECT OF THE SIXTH ANALYSIS IS FUTURE METHODS OF DIRECT FEDERAL INVESTMENT.

THE CURRENT METHODS OR MEANS OF FEDERAL FUNDING OF RESEARCH EQUIPMENT WILL BE EVALUATED. THE BENEFITS AND LIMITATIONS OF THESE METHODS AND THE PROS AND CONS OF CHANGING THEM WILL BE ASSESSED. ALTERNATIVES WILL ALSO BE EXPLORED WITH AN EYE TO MAXIMIZING THE RETURN TO THE NATION OF FUTURE INVESTMENT OF SCARCE FEDERAL RESOURCES. ONE OPTION THAT WILL BE EXPLORED IS THE FEASIBILITY OF RETURNING TO THE USE OF THE PROVEN BUT PRESENTLY UNUTILIZED MECHANISM OF GUARANTEED LOANS TO REHABILITATE UNIVERSITY RESEARCH LABORATORIES AND EQUIPMENT. AS THE COMMITTEE, KNOWS IN 1965 THE HIGHER EDUCATION ACT ESTABLISHED A GUARANTEED LOAN PROGRAM (TITLE VII-C) DESIGNED TO ASSIST WITH THE REHABILITATION OF ACADEMIC LABORATORIES, AND THAT PROGRAM PLAYED A SUBSTANTIAL LEADERSHIP ROLE IN MOBILIZING OTHER STATE, PRIVATE, AND INSTITUTIONAL FUNDS. FOR MORE THAN A DECADE, HOWEVER, THAT LOAN PROGRAM HAS NOT BEEN FUNDED. REINVESTMENT IN THE TITLE VII PROGRAM IS ONE OPTION; OTHERS WILL BE CONSIDERED.

THE PROJECT CONTRACTED WITH THE ACCOUNTING FIRM COOPERS & LYBRAND TO DO THE RESEARCH AND ANALYSIS ON SEVERAL OF THE ANALYSES: DEBT FINANCING, TAX INCENTIVES, FEDERAL AND STATE REGULATIONS, AND FUTURE METHODS OF DIRECT FEDERAL INVESTMENT. THE ANALYSIS OF OPPORTUNITIES FOR IMPROVEMENTS IN UNIVERSITY PROCUREMENT, MANAGEMENT, AND USE OF EQUIPMENT IS BEING CARRIED OUT BY A TEAM OF THREE UNIVERSITY PEOPLE: DAVID LITSTER, DIRECTOR OF MIT'S MATERIALS SCIENCE CENTER; ROBERT BOCK, DEAN OF THE GRADUATE SCHOOL AT THE UNIVERSITY OF WISCONSIN; AND JULIE NORRIS, ASSISTANT PROVOST OF THE UNIVERSITY OF HOUSTON. OVER THE NEXT FOUR MONTHS THEY WILL VISIT AND GATHER INFORMATION FROM 12 UNIVERSITIES AND 8 CORPORATE AND GOVERNMENT LABS.

PHASE II

DURING THE SECOND PHASE OF THE PROJECT, BEGINNING IN THE FALL OF 1984, THE RESULTS OF THE SIX ANALYSES WILL BE DISSEMINATED TO THE UNIVERSITY COMMUNITY. LEADING HIGHER EDUCATION ASSOCIATIONS AND SCIENCE AND ENGINEERING SOCIETIES WILL BE INVITED TO JOIN THE PROJECT AS COOPERATING ORGANIZATIONS AND TO HOST SPECIAL SEMINARS, AS PART OF THEIR REGULARLY SCHEDULED MEETINGS. REGIONAL WORKSHOPS WILL BE HELD IN SEPTEMBER AND OCTOBER 1984. THEY WILL BE DESIGNED TO PROVIDE OPPORTUNITIES FOR TEAMS OF REPRESENTATIVES FROM UNIVERSITIES IN EACH REGION TO SHARE THEIR VARYING PERSPECTIVES ON THE EQUIPMENT PROBLEM. DURING THE WORKSHOPS EACH TEAM WILL BE INVITED TO EXPLORE THE IMPLICATIONS FOR THEIR OWN INSTITUTIONS OF ADOPTING APPROACHES IDENTIFIED BY THE PHASE I ANALYSES.

PHASE III

THE PROJECT'S FINAL PHASE WILL BE AN AGENCY BRIEFING IN WASHINGTON TO REPORT THE RESULTS OF THE PROJECT TO THE SPONSORING FEDERAL AGENCIES AND TO THE CONGRESS. A FINAL REPORT WILL BE SUBMITTED TO THE SPONSORING AGENCIES IN JANUARY 1985.

OBSOLETE FACILITIES--THE OTHER SIDE OF THE EQUIPMENT PROBLEM

ANY DISCUSSION OF THE RESEARCH INSTRUMENTATION NEEDS OF UNIVERSITIES IS INCOMPLETE IF IT DOES NOT ALSO ADDRESS THE INTERRELATED RESEARCH FACILITIES PROBLEM. MODERN RESEARCH INSTRUMENTATION INCREASINGLY REQUIRES SPECIALIZED ENVIRONMENTS, AND MANY OF OUR RESEARCH LABORATORIES ARE OBSOLETE AND INADEQUATE SETTINGS FOR MODERN SCIENCE. THEY OFTEN REQUIRE EXTENSIVE AND COSTLY MODERNIZATION OR REPLACEMENT.

THE DIMENSIONS OF THE FACILITIES PROBLEM ARE ESTIMATED TO BE CONSIDERABLE. IN 1981 THE AAU SURVEYED THE FACILITIES NEEDS OF 15 MAJOR UNIVERSITIES. IN FY 1979 THESE INSTITUTIONS ACCOUNTED FOR ABOUT 22% OF TOTAL FEDERAL OBLIGATIONS FOR UNIVERSITY-BASED RESEARCH. THE SCOPE OF THE SURVEY INCLUDED THE NEEDS OF ONLY PRESENT PROGRAMS AND FACULTY; PLANNED NEW PROGRAMS AND NEW HIRES WERE EXCLUDED. IT FOUND THESE INSTITUTIONS ABLE TO MEET ONLY ABOUT HALF OF THEIR PROJECTED NEEDS FOR REPLACEMENT CONSTRUCTION, MODERNIZATION, REPAIR AND RENOVATION, AND HIGH-COST EQUIPMENT (ITEMS CAPITALIZED AT MORE THAN $100,000). THE REPORT'S EXECUTIVE SUMMARY IS ATTACHED TO MY STATEMENT (ATTACHMENT D). THIS REPORT ALSO HAS BEEN PROVIDED TO THE STAFF.

THE FACILITIES DEFICIT IS ALMOST CERTAINLY THE MOST SERIOUS LONG-RANGE PROBLEM THAT NOW CONFRONTS OUR RESEARCH UNIVERSITIES AND THE AGENCIES FOR WHICH UNIVERSITY RESEARCHERS PERFORM RESEARCH. A RECENT SURVEY BY THE UNIVERSITY OF CALIFORNIA, FOR INSTANCE, FOUND "STAGGERING" FACILITIES PROBLEMS, INCLUDING ESTIMATED NEEDS FOR CORE ACADEMIC FACILITIES ALONE TOTALING $1.6 BILLION OVER THE NEXT DECADE. TRADITIONAL FUNDING APPROACHES, THE UNIVERSITY CONCLUDED, SIMPLY WILL NOT MEET THEIR NEED FOR FACILITIES REHABILI-

TATION AND REPLACEMENT. FAILURE TO ADDRESS THIS BACKLOG, HOWEVER, WILL CERTAINLY RESULT IN COMPROMISED INSTRUCTIONAL AND RESEARCH PROGRAMS.

WE UNDERSTAND THAT THE NATIONAL SCIENCE FOUNDATION HAS JOINED WITH THE DEPARTMENT OF DEFENSE AND WITH OTHER AGENCIES IN PLANNING A COMPREHENSIVE STUDY OF THE PROBLEM. WE ARE PLEASED INDEED THAT THE FOUNDATION IS IN A LEADERSHIP POSITION TO HELP DEVELOP BOTH A BETTER UNDERSTANDING OF THE PROBLEM AND SUITABLE SOLUTIONS.

THE PROBLEM ALSO HAS GAINED THE ATTENTION OF 18 MEMBERS OF THE SENATE WHO HAVE JOINED AS COSPONSORS OF SENATE BILL 1537, "THE UNIVERSITY RESEARCH CAPACITY RESTORATION ACT OF 1984." THIS BILL OFFERS A SOUND BLUEPRINT FOR ACTION BY THE NSF AND BY FIVE OTHER AGENCIES. IT CALLS ON EACH OF THESE SIX AGENCIES TO INVEST IN THE REHABILITATION OF THOSE UNIVERSITY LABORATORIES IN WHICH AGENCY RESEARCH PROGRAMS ARE CARRIED OUT. WE HOPE A SIMILAR INVESTMENT PLAN WILL GAIN SUPPORT IN THE HOUSE.

RECENTLY THE NATIONAL COMMISSION ON STUDENT FINANCIAL ASSISTANCE (A BIPARTISAN PANEL CREATED BY P.L. 96-374, THE EDUCATION AMENDMENTS OF 1980) COMPLETED ITS REPORT, "SIGNS OF TROUBLE AND EROSION: A REPORT ON GRADUATE EDUCATION IN AMERICA." THE COMMISSION AFFIRMS THE SERIOUSNESS OF THE INSTRUMENTATION AND FACILITIES DEFICITS AND IT CALLS FOR JUST SUCH AN INVESTMENT STRATEGY FOR RESEARCH INSTRUMENTATION AND FACILITIES REHABILITATION AS THAT PROPOSED BY S. 1537. WE COMMEND THAT REPORT TO THE COMMITTEE'S ATTENTION.

A SERIOUS DEBATE LEADING TO CONCRETE PROPOSALS FOR A FACILITIES REINVESTMENT STRATEGY IS NEEDED. WE HOPE THAT THIS COMMITTEE WILL CONSIDER THE FACILITIES PROBLEM AS PART OF ITS CONTINUING DELIBERATIONS ON THE RESEARCH EQUIPMENT PROBLEM AND THE FY 1985 NSF BUDGET REQUEST.

NSF ORGANIZATION

MY FINAL POINT CONCERNS PROPOSALS PENDING BEFORE THE COMMITTEE TO AMEND THE NSF CHARTER IN VARIOUS WAYS THAT, SOME BELIEVE, WOULD STRENGTHEN THE PLACE OF THE ENGINEERING DISCIPLINES WITHIN THE FOUNDATION. IT IS NEVER A HAPPY EXPERIENCE TO DISAGREE PUBLICLY WITH ONE'S COLLEAGUES IN THE RESEARCH COMMUNITY, BUT IN THIS INSTANCE THE CASE DOES NOT SEEM TO US PERSUASIVE ON ITS MERITS. THE PROPOSAL TO AMEND THE NSF ORGANIC ACT, CHANGE THE NAME OF THE FOUNDATION, AND FORCE CHANGES IN THE COMPOSITION OF THE NATIONAL SCIENCE BOARD, ARE UNWISE AND UNNECESSARY. FOR SOME TIME, IT IS TRUE, THE ENGINEERING PROGRAMS OF NSF WERE DISADVANTAGED RELATIVE TO THE REST OF THE FOUNDATION'S RESEARCH PROGRAMS. THAT, WE ARE PLEASED TO NOTE, NOW HAS CHANGED. PROSPECTS ARE MUCH BRIGHTER.

FROM TIME TO TIME SUCH PROPOSAL HAVE BEEN OFFERED BY ONE OR ANOTHER DISCIPLINE OR DISEASE GROUP AT THE NIH AS THEY SEEK STATUTORY RECOGNITION AND PRESUMED ADVANTAGE. THESE ASSOCIATIONS HAVE CONSISTENTLY OPPOSED SUCH ATTEMPTS THERE AS BEING UNNECES-

SARY, AND POTENTIALLY DIVISIVE. FOR THE SAME REASONS WE OPPOSE THIS PROPOSAL TO AMEND THE NSF ORGANIC ACT. WE ASK THE COMMITTEE TO REJECT THE PROPOSED AMENDMENTS.

THANK YOU, MR. CHAIRMAN, FOR THIS OPPORTUNITY TO PRESENT OUR VIEWS TO THE COMMITTEE. I WILL BE PLEASED TO RESPOND TO QUESTIONS.

ATTACHMENT A

PROJECT TO ASSESS & DISSEMINATE ALTERNATIVE APPROACHES TO MEETING UNIVERSITY RESEARCH EQUIPMENT NEEDS

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ATTACHMENT B

A
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Association of American Universities

AAU STATEMENT ON DECISION MAKING IN FEDERAL FUNDING FOR RESEARCH FACILITIES

The Association of American Universities represents institutions whose faculties are deeply engaged in research. We share with many other institutions and individuals a commitment to advancing the quality of the nation's research effort. Since the vitality of this effort is closely linked to the soundness of decisions made about science by public bodies, it is both appropriate and important for the AAU to state its collective views about the ways in which those decisions are best made.

The United States has evolved an admirable but fragile system of awarding federal funds for research. In general, Congress appropriates funds for the support of broad categories of research. Subsequently, the administering federal agency issues guidelines for making applications in a manner that assures fair and open competition. Researchers then submit detailed proposals that are judged by experts, scientists chosen for their ability to make sound and careful judgments in the scientific area involved. This method maximizes the scientific return on the federal investment by assuring that awards are made on the scientific merit of the proposal and the professional merit of the proposer.

The same method governed most federal programs in support of scientific facilities when such programs existed. However, in the early 1970s, most federal government programs in support of the construction and renovation of research facilities ended. The subsequent decade-long failure to attend to the capital base of university science has led to a backlog of need that has hampered American science and placed great stress on the processes by which the government allocates scientific resources.

We believe that processes based on the informed peer judgments of other scientists need to be preserved and strengthened. We therefore urge scientists, leaders of America's universities, and Members of Congress to support the practice of awarding funds for the support of science on the basis of scientific merit, judged in an objective and informed manner. Further, we urge them to refrain from actions that would make scientific decisions a test of political influence rather than a judgment on the quality of the work to be done. These principles should apply in making decisions about scientific facilities as well as in awarding funds for research projects.

Finally, we urge officials of the national Administration and Members of Congress to deal promptly with the decay of the physical plant that houses much of the nation's basic research. S.1537, introduced by Senators Danforth and Eagleton, is a bipartisan effort to deal with this national priority and deserves strong and prompt support.

October 25, 1983

Suite 730 • One Dupont Circle • Washington, DC 20036 • 202/466-5030

National Association
of State Universities
and Land-Grant Colleges

Robert L. Clodius, President

STATEMENT ON FEDERAL FUNDING OF ACADEMIC FACILITIES

In recent years, federal funding of various higher education programs had decreased markedly. In particular, wholly inadequate resources for facilities has led some institutions to seek direct assistance from Congress. The outcome of such a process could be an irrational system of distribution based solely on political influence. In that regard, the National Association of State Universities and Land-Grant Colleges shares the concerns of the Association of American Universities, the National Academy of Sciences, and others, that this approach is unacceptable, in that it could diminish the capability of higher education to carry out its mission in education and research, and we urge Members of Congress and leaders of colleges and universities to refrain from this practice.

We further urge the Congress to fund Title VII of the Higher Education Act and similar programs in other agencies at reasonable levels, and to insure the systematic allocation of resources to satisfy pressing national concerns.

November 13, 1983

One Dupont Circle, N.W. Washington, D.C. 20036 202 / 293-7120

The Council of Graduate Schools in the United States
One Dupont Circle, N.W. Suite 430 Washington, D.C. 20036-1173 Phone: 202/223-3791

RESOLUTION NO. 1

RESOLUTION IN DECISION MAKING IN THE FEDERAL FUNDING FOR RESEARCH FACILITIES

WHEREAS the United States has evolved an admirable but fragile system of awarding federal funds for research, and.

WHEREAS this system is dependent upon fair and open competition responding to federal agency guidelines, and peer review judgment by experts in the scientific area to be studied, and,

WHEREAS this method of peer review has governed most federal programs in support of scientific facilities when and where such program exist, and,

WHEREAS most federal programs to support construction and renovation of research facilities have been ended through a shifting of federal priorities, and,

WHEREAS in the absence of such programs colleges and universities are suffering a gradual increasing erosion in their ability to support state-of-the-art research in all scientific fields, and,

WHEREAS CGS member institutions share with many other institutions and individuals a commitment to advancing the quality of the nation's research effort. The vitality of this effort is closely linked to the soundness of decisions made about scientific research by public bodies.

NOW THEREFORE BE IT RESOLVED that the Council of Graduate Schools supports the recently adopted AAU Statement on Decision Making in federal funding for research facilities. CGS urges the national Administration and members of Congress to support the practice of awarding funds for research or facilities on the basis of scientific merit judged in an objective manner. CGS would further urge support for new spending authorities to support research facilities to keep our nation's investment in academic research facilities from becoming out of date.

Passed at the CGS 23rd Annual Meeting 12/83

Adopted at the Board of
Directors meeting of
2/23/84

Ruth A. Abdouch
Executive Secretary
Board of Directors

AMERICAN COUNCIL ON EDUCATION

5. Federal Relations Report
    B. Proposed Statement on Federal Funding of Research and Instructional Facilities

For Board Approval

BOARD OF DIRECTORS
Meeting of February 23, 1984
10:00 a.m.-3:00 p.m.
Kellogg Room
One Dupont Circle
Washington, DC

AMERICAN COUNCIL ON EDUCATION
Office of the President

MEMORANDUM

TO: ACE Board of Directors

FROM: J. W. Peltason

SUBJECT: Proposed Statement on Federal Funding of Research and Instructional Facilities

DATE: January 9, 1984

Community concern has been generated by the recent attempts of several institutions to bypass the customary review process to obtain federal funding for research facilities. The Association of American Universities last fall issued a statement urging scientists, leaders of America's universities, and members of Congress "to support the practice of awarding funds...on the basis of scientific merit...(and) to refrain from actions that would make scientific decisions a test of political influence rather than a judgment on the quality of the work to be done."

Similar statements have been issued subsequently by the National Academy of Sciences, the National Association of State Universities and Land-Grant Colleges, and the American Association of State Colleges and Universities. The ACE Commission on Governmental Relations discussed this matter at its fall meeting, and recommended that the Board adopt the following statement:

"There is a pressing need for increased federal support for the rehabilitation of research and institutional facilities. Established procedures for these support programs involve a system of review to assure equitable consideration and the awarding of funds on the basis of merit.

"At a time when fiscal constraints have severely restricted many federal programs, it is especially important to sustain the process which assures systematic allocation of scarce resources. Therefore we call upon leaders of the academic community and members of Congress to reaffirm the principle of broadly representative review of project proposals in fair and open competition, so that funding decisions continue to represent the best interests of both higher education and the national welfare."

One Dupont Circle, Washington, D.C. 20036-1193
President (202) 833-4710 Vice President (202) 833-4712

ATTACHMENT C

THE SCIENTIFIC INSTRUMENTATION NEEDS
OF
RESEARCH UNIVERSITIES

A Report to the National Science Foundation
by the
Association of American Universities

June 1980

The Scientific Instrumentation Needs of Research Universities

EXECUTIVE SUMMARY

OBJECTIVES OF THE STUDY

- assess the current status of scientific instrumentation in major research universities
- identify factors which facilitate or impede its development, acquisition, use, and maintenance
- estimate the future consequences of present funding policies
- recommend appropriate policy changes

METHODOLOGY

- sixteen universities, six national and government laboratories, and nine commercial laboratories were visited; about 80 department heads and over 250 researchers and research administrators were interviewed in the universities; in addition, the views of approximately 60 researchers and research managers were gathered in visits to national, government, and commercial laboratories
- five fields of science and engineering were studied: physics, chemistry, biological sciences, earth sciences, and electrical engineering
- numerical data on instrumentation acquisition, age, and replacement were gathered from 14 universities and four commercial laboratories

THE PROBLEM

Instrumentation is essential for progress in experimental research. Scientific knowledge has advanced rapidly; new instruments, more costly but qualitatively superior to earlier ones, have allowed measurements previously impossible. The rate of change has been great, competition among researchers intense. The capacity of university researchers to work at the frontiers of knowledge has important consequences for the nation's future research productivity and for the training of future generations of scientists and engineers.

The federal government has adopted a variety of funding policies for the support of research instrumentation: the competitive project system, special instrumentation programs, formula grant programs, block-funded centers, federally sponsored research centers, and regional instrumentation centers chief among them. For about 15 years, federal support for basic research has gradually declined; now support levels are further strained by rapid inflation. But inflationary price increases are simply the rising baseline upon which are superimposed the frequently much larger increases resulting from instrumentation advances.

ASSESSMENT

The great diversity of instrumentation needs found among institutions visited precludes simple generalizations. However, problems in the acquisition, use, and maintenance of research instrumentation were found in all of the leading universities visited. The precise configuration of these needs and problems varies widely. The capabilities of institutions and departments to meet them do also.

University researchers face great difficulty in replacing worn-out or obsolete instrumentation and in acquiring new instruments needed for frontier research. A comparison of university instrumentation inventories with those of two leading commercial laboratories reveals that the median age of university equipment is *twice* that of the commercial laboratories' instrumentation. Even the nation's major research universities have not kept pace in meeting instrumentation needs. Researchers heavily dependent upon federal funds have witnessed grant size fall behind escalating research requirements. As a result, many work with inadequate tools that impair the pace of research, force closure of lines of inquiry, strain operations and maintenance budgets, and compromise the advanced education of graduate students.

Start-up funds for new faculty often are shrinking as costs rise. Support equipment is needed to test, calibrate, and augment primary instruments. Often it is especially difficult to fund. Funding for operation and maintenance costs is increasingly difficult to obtain. As a result, faculty and students sacrifice research time to these routine tasks.

Many research facilities are in need of renovation or replacement; federal funding for these purposes has decreased, however, and universities lack the funds to respond. Signs that aging facilities now impede research were found in many laboratories and support facilities.

Local university needs vary widely, reflecting the unique circumstances under which each institution operates and the great diversity between and even within the five fields studied. Present funding policies do not provide sufficient flexibility to deal with such local circumstances.

When compared with government and commercial laboratories visited, most university laboratories fare poorly. The best-equipped industrial laboratories surpass almost all university laboratories visited. One university researcher captured the sense of disparity and observed, "the ivory towers are now in industry." The director of one leading industrial research laboratory described the struggle of university researchers as he has observed them as "pathetic." When asked to contrast their laboratories with foreign laboratories, a number of university researchers stated that many, most notably those in Japan and West Germany, are now superior.

CONCLUSION

The quality of research instrumentation in major university laboratories has seriously eroded. Not all, but many researchers in the nation's best-funded universities are struggling to work effectively with obsolete tools. The equipment being used in the top-ranked universities has a median age twice that of the instrumentation available to leading industrial research laboratories.

Three *causes* are identified:

- a relative decrease in instrumentation support
- inflexibility within the project system
- insufficient support for maintenance

Three major *consequences* are:

- diminished research productivity
- reduced training capacity
- decline in international competitive status

RECOMMENDATIONS

Federal policy for the support of research instrumentation should provide for a basic three-part funding strategy:

- strengthen instrumentation funding in the project system
- expand special instrumentation programs
- create in the National Science Foundation a new, supplemental formula grant program to provide needed flexibility to meet diverse institutional needs

FUTURE STUDIES

Five studies are recommended: 1) a thorough analysis of foreign research funding policies and programs and their implications for the competitive stature of American science should be undertaken; 2) a study of cooperative research arrangements between industries and universities and the factors—including federal policies—that encourage and discourage them is needed; 3) the planned assessment of regional instrumentation centers should include consideration of the concerns documented in this report; 4) universities should assess current instrumentation policies and develop mechanisms and incentives designed to promote effective sharing of instrumentation; 5) an assessment of the costs and benefits of federally-mandated equipment inventory and reporting systems should be undertaken.

ATTACHMENT D

THE NATION'S DETERIORATING UNIVERSITY RESEARCH FACILITIES

A Survey of Recent Expenditures and Projected Needs in Fifteen Universities

July 1981

Association of American Universities
One Dupont Circle, N.W.
Washington, D.C. 20036

EXECUTIVE SUMMARY

OBJECTIVES OF THE SURVEY

This survey of 15 leading universities had three objectives:

-- In the institutions surveyed, document expenditures for research facilities and major ($100,000 or more) equipment, without regard to source of funds, over the last four years in the following six fields:

- Biological Sciences
- Chemical Sciences
- Earth Sciences
- Engineering
- Physics
- Medical Schools (10)

-- Provide responsible estimates, prepared by those universities, of expenditures for research facilities and major equipment that would be required over the next 3 years to meet the research and training needs of only current faculty.

-- From researchers and department heads, acquire assessments of the major consequences for science, industry, and government if the accumulating facilities needs of their institutions are not addressed.

FINDINGS

In many of the science and engineering departments surveyed, a substantial backlog of research facilities and equipment needs is accumulating. Projected funding needs over the next three years equal almost twice the level of expenditures by universities for their research laboratories and equipment over the past four years. Already, institutions often are unable to provide their basic science and engineering researchers and students with either the modern laboratories or equipment needed to conduct state-of-the-art research and education programs.

The loss of federal contributions to the support of research facilities and the absence of compensatory sources of support has forced many institutions to renovate and repair only those facilities in greatest need. Even this work often is carried out in a necessarily piecemeal fashion which is uneconomical over the long term. Working under such conditions, researchers unavoidably compromise their productivity and future competitiveness.

Relatively few construction projects have been completed in recent years in a majority of the physical sciences and engineering departments surveyed. Many institutions estimate substantial needs for new laboratories, for the expanded modernization and repair of old laboratories and for modern research equipment. Details are provided in the following report and the appendicies. The survey's principal findings are the following:

- In the last four years, for the six fields surveyed, fifteen leading universities together spent $400 million from all sources for facilities and major equipment. Half of those expenditures was for a relatively small number of new construction projects; the remaining half, spread over a larger number of generally less costly funding projects, was for facility modernization, major repair and renovation, and special purpose research equipment.

- In the next three years, the 15 universities estimate they should spend almost twice as much ($765 million) just to provide the necessary research facilities and special research equipment for current faculty only. These estimates are in current dollars and, therefore, do not include the added effects of inflation.

- New construction to replace outmoded facilities accounts for almost 60% of total projected funding requirements across all fields.

- In addition, substantial needs for major research equipment were identified in all six fields. These equipment estimates include only major items costing at least $100,000. As the 1980 AAU report to the National Science Foundation found, most departments also have serious deficiencies of less costly analytical instrumentation and support equipment.

RECOMMENDATIONS

The problems of obsolescence in the nation's university research facilities have been growing for more than a decade. To solve them, a new national investment strategy is needed. That strategy should provide direct, balanced support for university facilities from federal agencies and provide investment incentives designed to involve industry, the states, and the universities in a coordinated effort. The following steps are suggested as starting points:

1. Key Executive agencies should develop a mechanism to periodically assess the condition of university research laboratories and the consequences for the nation of that condition. Such assessments should involve the Office of

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Science and Technology Policy, the National Science Foundation, the Department of Defense, the Department of Energy, the Department of Health and Human Services, the Department of Agriculture and the National Aeronautics and Space Administration. The views of industry and the universities also should be solicited.

If the initial review corroborates the assessment of this suvey the following recommendations should be considered:

2. The facilities and equipment program earlier proposed to be undertaken by the National Science Foundation but deferred should be restored as a priority initiative in FY 1983.

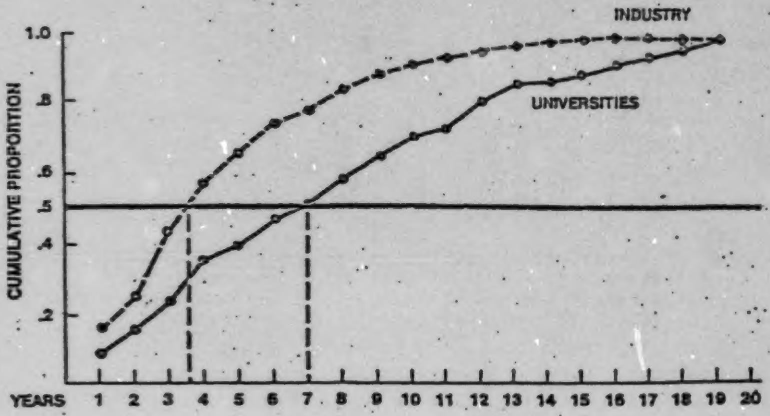
3. The Department of Defense, Department of Energy, the National Aeronautics and Space Administration, the Department of Health and Human Services, and the Department of Agriculture should establish research instrumentation and facilities rehabilitation programs targeted on the fields of science and engineering of primary significance to their missions. The National Science Foundation should assist in the development, implementation, and coordination of those activities.

4. Incentives should be provided to encourage industries and the states to join with universities and the federal government in renewing the nation's university research laboratories.

5. Interest costs incurred in the construction, modernization, renovation, and repair of facilities in which federally supported research programs are carried out should be allowable indirect costs under OMB Circular A-21.

ATTACHMENT E

Age of Instrumentation in Universities Twice That in Industry



Mr. **Walgren**. Well, thank you very much, Dr. Rosenzweig.

Let me begin. Let me ask you both to comment on the organizational structure of NSF in general as opposed to any specific change in the Organic Act or something to that effect, and its ability to take proper account of the contribution that engineering has to make in this society. As Dr. Harrison says, this is largely a question of use in many ways of technology. That whole side of it seems to follow more in what might be defined as engineering, and there is—I would think it would be fair to say—the possibility that the engineering component of our scientific capability be substantially left out.

It has been suggested that, organizationally, it just is not brought to the fore with the intensity that specific physical science investigatory projects have.

Can you comment on whether or not there ought to be an organizational approach, a change made within the structure of the National Science Foundation, incorporating more engineers; or how do we get them to be able to compete properly for their budget and the value judgments that are made in that distribution?

Dr. Harrison?

Dr. **Harrison**. In the first place, I would like to make a few comments on the relationship of engineering to science. Incidentally, make a distinction between engineering and what engineers do. Engineers may do a lot of things which are not really what engineering is in the sense we are talking about here; namely, the research aspect of it, the process of investigation of how to solve problems; in the same sense that there are a lot of scientists, chemists, for example, that do things that do not have to do with the investigation of chemical phenomena. They may be in quality control or something of this sort, but that are not in the investigative mode.

I am convinced that science and engineering are moving closer and closer together and that many investigations now involve simultaneously the investigation of phenomena and the investigation of how to use that phenomena to solve some problem.

This, I think I can say with more confidence than I can a lot of other things, also represents the position of the AAAS board. We have recently gone through a discussion on this matter and in fact are moving to recommend to the AAAS Council that the goals of the AAAS be changed to recognize the degree that engineering and science are coming closer and closer together.

It is sort of amusing because both of them are proliferating disciplines. But the overall proposition is of science and engineering seeming to us to be coming closer and closer together.

We would recommend the consideration of any types of activity that would tend to enhance that merging of the two, or approaching that merging.

Now, changing the NSF Organic Act could be one approach, but there are probably others, and so I would not like to take a position yes or no on that.

There are a number of engineers on the National Science Board. The number that occurs to me at the moment is five. That may or may not be correct. The engineering point of view is well represented on the Board at this time.

I don't think, in the way the Board operates—at least the way it operated when I was on it—it is not a question of head count of how many people but of having someone that articulates a point of view. And that is there.

Engineering is clearly being strengthened within the National Science Foundation, and this is highly feasible in a period in which budgets in the National Science Foundation are expanding.

If it came to a period in which that was not true, then you would be coming to a stronger defense of your turf, be it engineering or science, and that would be difficult.

Mr. **Walgren**. Let me ask you whether you are concerned with the idea that if there is a capital item, a large, high-energy physics—although maybe that would not quite come out of this budget—I don't mean to speak exactly—but I understand we are now going to be developing this very long baseline array of radiotelescopes. A large capital item comes along. Does that have the effect of squeezing out other essential efforts that are soft in their presentation, or not physical, and should the NSF have a capital budget that is sharply distinguished from its physical investments?

That probably cuts several ways because I suppose you could say the whole instrumentation phenomenon is a hard capital item and spread across a lot of disciplines. It has the potential to squeeze out a lot of efforts. But shouldn't we be distinguishing between that and trying to set those things very carefully aside for fear that they will affect the rest of the effort?

Dr. **Rosenzweig**. I think we ought to have a better way than we have now of assessing our capital needs in science. Whether that results in a separate formal capital budget within the Foundation or elsewhere, I am not sure, but we don't have a very good grip on the Nation's capital agenda for science right now or into the future, and to develop that would, I think, be quite useful.

I think the experience in the past, Mr. Walgren, has been that the development of large and interesting new facilities has added to the support for science overall rather than subtracted from the support of some other aspect of science. But until now, at any rate, exciting work has commanded its appropriations and not at the expense, generally, of other work that was also interesting.

I think that says something about the standing of engineering, too, to go back to your first question. I don't feel that the problems of engineering within the Foundation or within universities, for that matter, have been or are primarily organizational problems, so that they can be solved by organizational changes.

I think the creation of an Engineering Directorate within the Foundation was a good idea. Essentially, what happened in the development of science in this country is that we went through quite a long period after the war in which, really, the most exciting scientific problems were those of fundamental research. They were seen that way very widely, and they commanded the greatest resources.

I think that was to some extent shortsighted, but it was certainly understandable given the developments of biology and the developments of high-energy physics and all of the other interesting areas of science. Engineering began to make a comeback when it began to contribute to that process, and I think the development of computers was the earliest harbinger of that. The development of computer science within the universities and certainly its reflection within the Government establishment was a joint creation of mathematics, applied mathematics, and electrical engineering.

Biomedical engineering has followed a similar course in which people who never had anything to do with one another suddenly came together from medical schools and from biology departments and from schools of engineering because there were exciting intellectual opportunities in the marriage of those areas, and that, too, has been reflected in the Foundation and in the funding for engineering.

I don't sense that the problem of engineering is as great now as it used to be. I don't think that it is a problem that needs structural redress. And I think that so long as the intellectual challenges coming up out of the fields of engineering and in the marriage of engineering with basic science, as long as those intellectual challenges remain on the forefront, that engineering is going to get its fair share of money and attention.

Mr. **Walgren**. I don't mean to continue because I know others have points they would like to raise.

Dr. **Harrison**. May I comment?

Mr. **Walgren**. Certainly.

Dr. **Harrison**. I believe the question is not one of what any scientific discipline needs; it is what is the need of the Nation for what that discipline can contribute, not necessarily in the short term, or more particularly not in the short term, but in the long term.

That is one of the bases on which I would support engineering—very carefully looking at engineering. Distinguish between what engineers do and what engineering is as research—the investigation of how to solve problems. This ca[illegible]e very sophisticated and very creative.

One criticism that I would have of the budget, or one place that I would be inclined to raise a question, is why the Foundation is funding the types of engineering it is funding. They are the standard ones that have been with us for ages. I personally would be interested in seeing the funding to be such that it leads schools of engineering to develop in the directions which are coming to the forefront now.

Now, in reference to astronomy, my understanding is that the astronomers have been rather good in being able to agree amongst themselves where big investments should be made. This would be one of the questions I want to look at as to whether in fact the very large baseline, very long baseline, is coming from the astronomy community or not.

It is a fantastic capability. My feeling is, from the very beginning, it should be handled in such a way that that would be a resource for the scientists of the world, not just in this country. You don't redo that again, at least not in the Northern Hemisphere.

Mr. **Walgren**. Let me ask Dr. Rosenzweig, you indicated that we might have been somewhat shortsighted. Without focusing solely on the negative, but realizing that it is the negative, or our shortcomings, which hurt us, I cannot help but be struck by things such as, in the social and economic sciences. Our effort there is very small, and it is hard to break it apart, but in the overall it is very small; and yet when you put the president of General Motors on "Face the Nation" and ask him what is troubling him, he says, "If I could only get my people to come to work, we'd be fine."

Of course, all of us want to try to fill in the down parts of the cycles because we are always unable to do what we want to do in the future because we are lacking the resources from the recessions and the down parts of the cycle. Is there any organizational way that you could suggest that we could try to be less shortsighted in our allocation of these resources?

Dr. **Rosenzweig**. I think that openness and free communication and an opportunity to make a case over time probably are the critical elements. I just don't think organization makes up for fundamental problems in the underlying structure.

For example, I said we were shortsighted in our support of engineering, and I believe that, but I am not convinced that had we had what the proposed legislation calls for in place in the National Science Foundation, that we would have done much better in the first place, or that the decisions made would have been of a higher quality, and I can imagine circumstances in which the existence of a bureaucratic structure carries forward into the future commitments that long outlive the usefulness that brought the structure into being initially.

I think you choose your advantages when you create an organization, but you also choose some disadvantages with any form of organization, and one of the things you choose when you create a new organization is a rigidity—the advantage you get is a voice for the function you have created. The disadvantage you get is a rigidity that requires that that voice be heard and perpetuate itself into the future because it exists, even if the time should come when priorities change and therefore funding and programs ought to change, also.

So I think it is probably a mistake to look for organizational fixes for what are underlying social and intellectual developments.

Mr. **Walgren**. But at a time when we can truly anticipate economic revolution, wouldn't it be wise to organizationally institutionalize changing applications?

Dr. **Rosenzweig**. I think the problem with the social sciences is quite a different one. I am a social scientist myself, so you have struck a responsive chord in me. The problem we have had in the social sciences in the last few years in this country has not been structural; it has been political. It is that this administration doesn't like social science, and it has made that clear year after year, at every opportunity, not only in the National Science Foundation but in the National Institutes of Health and the Department of Agriculture and wherever it has encountered the social sciences.

The NSF budget is a little better this year than it has been in the past, and that is encouraging, particularly if that indicates an upward movement rather than just a one-time change. But no structure in the world is going to change the fact that the people who run this administration are hostile to the social sciences.

Mr. **Walgren**. I see. Thank you very much.

Mr. Brown?

Mr. **Brown**. I appreciate the testimony which you have both offered. I find that you are in general agreement that we have a relatively good budget this year. As a matter of fact, when I recall back to the hearings that we had in 1981, when we were confronted with the changes that were made by this administration in the first NSF budget that they had control over, I am ecstatically happy at the change that has taken place.

You both also seem to agree that we are still shorting the science and engineering education somewhat. In your last remarks, Dr. Rosenzweig, you seemed to me to indicate that you would agree with Dr. Harrison that perhaps we are not emphasizing the social sciences, behavioral sciences, as strongly as you might prefer, and certainly I have that feeling about it.

I don't know how much of a fight to make out of it because we are still doing better than we were doing in previous years.

I would like to explore with you what we can do to change this attitude on the part of the administration that you commented on. It seems to me that as you look at the performance of our society as a whole over the past several years in relationship to our competitive societies, the problem has not been in the strength of our basic science effort but in the strength of our application of that science to social problems, which would generally be construed as engineering and management sciences in general.

Do you perceive that in the same way? I will ask that of each of you. In other words, our decline in economic competitiveness, our feeling that we are not enjoying the quality of life that we should, stems not from the fact that we are not still winning Nobel Prizes but the fact that we are not applying this knowledge as adequately as we should.

Dr. **Rosenzweig**. I wish I could claim so much credit for my colleagues in the social sciences. I don't think we are responsible for the decline in American competitiveness or the problems of American industry or that we have it within our power, even with all the funding that we think we deserve, to solve those problems.

I think that we can help to understand better than we do now what has gone wrong and what kinds of alternatives might be effective, but the solutions, I have to say, are based on political will rather than knowledge generated by research.

Dr. **Harrison**. May I comment on that?

Mr. **Brown**. Well, I think you made that same kind of comment, didn't you?

Dr. **Harrison**. I have lost what I was going to say now.

Mr. **Brown**. Well, we are talking about how we can change the attitude of the administration.

Dr. **Harrison**. Oh, I know. I would like to suggest that social scientists get asked the wrong questions. That is, as a scientist, as a student of, one studies phenomena and knows what its characteristics are.

When you come down to resolving any societal issue, it is not the scientific and the engineering and the scientific community that resolves the societal issue; it is society that resolves societal issues.

You eternally come up against a value judgment. Those value judgments are the prerogative of the public or the surrogates of the public: you, gentlemen and ladies.

Now, what a scientist can do is to identify problems, assess the nature and magnitude of those problems, determine what additional information one needs in order to address them, possibly go get that information, be it of the engineering type, the solving-of-problem type, or the other; suggest options; assess, insofar as possible, the total probable negative impact, the total probable positive impact; articulate that in such a way that the public can understand it. And then the decision is in the hands of the surrogates of the public, or the public.

Run this through with waste disposal, for example. We can cope with the technicalities of it, but we cannot site anything; we cannot locate it. These are kinds of questions, you know, that go to the community.

Now, quite frankly, I think it highly inappropriate to ask a scientist what to do. What they can do is to tell you these are the options and these are the consequences that you may expect to follow from it.

Mr. **Brown**. Well, I don't want to belabor this point, but I have in my mind, as we look at this problem, the teachings of Professor Demming, who is generally considered to have transformed the Japanese system. He didn't give them any new scientific insight. As a management professor, he went over there and said, Look, you can steal all of the technology and science from the United States that you want, but you have got to use it to improve your production, the quality of your product—which was recognized by the Japanese in the fifties as being low—and the quality of your production in general, the economics of it, so that you can compete with the United States.

Dr. **Harrison**. He said the same thing in this country.

Mr. **Brown**. Yes, he is saying the same thing over here. Now, we are just beginning to recognize that what he is saying is probably true. As I recall from my reading, he says the problem is 85 percent management, maybe 15 percent science and technology.

That is why I am suggesting that perhaps we ought to give more attention to those things which relate to the utilization of science, which is basically management coupled with economics, sociology, and a few other things like that.

Now, I know it is too complex a subject to get into right now, and I want to pick on Dr. Rosenzweig for just a moment.

Dr. Rosenzweig, you take umbrage at the proposal that Congressman Skeen and I made with regard to the changes in the NSF, and you suggest, by comparing this with the National Institutes of Health, that we are moving in the wrong direction. You say you have opposed this fragmentation of the National Institutes of Health.

I am relatively pleased that you are opposing us, because apparently your opposition there did not result in any constructive results.

Dr. **Rosenzweig**. You are absolutely right, Mr. Brown, absolutely right.

Mr. **Brown**. However, I don't quite grasp the similarities that you see. We are not proposing a fragmentation; we are proposing an integration. We are proposing that engineering be better integrated with the National Science Foundation.

My original proposal, which is still before the committee, to set up a National Technology Foundation paralleling the National Science Foundation, would have been susceptible to your criticism more aptly, I think, because it in effect says to the National Science Foundation, you've been trying to do good, but you ain't done good enough, so we're gonna put it somewhere else.

That would have been fragmentation, and you could, by a parallelism to the National Institutes of Health, have opposed it on that ground. Apparently, it still would not have made much difference because, as I say, your opposition to the fragmentation at NIH hasn't helped a great deal, hasn't changed it.

I am at a loss to understand the basis for your feeling. I presume that it is by instruction from your institutions. But I am trying to understand what their motivation is here if what we are both interested in—and I think we are—is strengthening the ability of the Foundation to deal with the important problems that face the society, and as we have repeatedly said, not in any way to weaken its support for the basic science role that it has been playing.

Now, you seem to feel, for one reason or another, that this would weaken that role, and I would like to have you tell me why.

Dr. Rosenzweig. Our feeling is that it has the potential to set up a kind of unhealthy competition within the Foundation. There may be a perfectly legitimate case for additional support and additional standing for engineering within the Foundation. I suspect that the same case can be made by other branches of science.

Mr. Brown. What other branches of science?

Dr. Rosenzweig. I don't know which ones, but they will be around. I can assure you they will be around.

Mr. Brown. We are not talking about branches of science. We are talking about that spectrum that extends from the creation of knowledge throuqh the application of knowledge through the commercialization of knowledge. That is a continuous web. It cannot be separated into separate sciences.

The comparison with the National Institutes of Health miqht be informative. Here dealing with human health involves both basic research and application. We don't separate it in the Institutes. The fundamental biological research would be what we have in the National Science Foundation. Engineering would be applying that to curing human disease. They don't separate it in the Institutes. They separate it by the type of disease, so that the comparable situation in the National Science Foundation would be if we had science and engineering and then separated by whether it helped the steel industry or the automobile industry or the textile industry or something like that, and had different institutes for these. That is what the National Institutes of Health would do.

Dr. Rosenzweig. Yes. I think we would argue that in NIH the separation of biological research along disease lines has had the effect of producing more money for research, and therefore it has helped research, but it has, paradoxically, also had the effect of building rigidities into research that have harmed the research effort.

Mr. Brown. Correct.

Dr. **Rosenzweig**. And so, in general, when somebody comes along with a proposal for a new institute, our answer is no, we don't think that is a good idea.

We opposed this year the effort of social scientists—successful so far; at least they managed to get the language into the House NIH bill—to get a fixed number or percentage of social scientists as members of NIH advisory committees. We think that is a bad idea, not because it is a bad idea to have social scientists on NIH advisory committees—that is a good idea—but because there is no basis for designating for a particular group of disciplines a particular number of slots or a particular status within the Institute, no basis that does not also apply to biologists, to physicists, to anybody else who has a claim on NIH money. It just seems to us to be moving in the wrong direction, away from the unity of science and toward a fragmentation by constituency.

Mr. **Brown**. I presume from what you are saying that you oppose the setting up of a separate National Technology Foundation.

Dr. **Rosenzweig**. Yes, that is correct.

Mr. **Brown**. You oppose that, and you oppose strengthening the National Science Foundation in its capability to deal with engineering.

Dr. **Rosenzweig**. No, sir, I don't oppose that. I am in favor of that. I am opposed to building that change into the NSF Organic Act.

Mr. **Brown**. You want it to happen, but you don't want to give any direction to it.

Dr. **Rosenzweig**. It is happening.

Mr. **Brown**. I know it is happening. The question is whether it is happening as adequately as is necessary.

Dr. **Rosenzweig**. Well, sure, that is a judgment call. I agree.

Mr. **Brown**. I would suggest that some of the pressure that has been brought about by the engineering community to call attention to the need has been beneficial.

Dr. **Rosenzweig**. Unquestionably. I agree with that.

Mr. **Brown**. I am still not sure where we differ, but we will explore it more later.

Mr. **Walgren**. Thank you, Mr. Brown.

Mr. Gregg?

Mr. **Gregg**. Dr. Harrison, you mentioned in your statement the NSF efforts in the area of math and science education. And you seem to imply, I guess fairly directly, that you don't feel it is up to snuff. Can you give me some specifics on that?

Dr. **Harrison**. Actually, the proposed budget for 1985 will effectively decrease by 20 percent the amount of money available to the precollege education. The appropriations would be the same in the 2 years, but one benefits by a carryover in 1984 that would not be true in 1985.

There is that question of magnitude of funding. There is also the question that the program descriptions in the backup book for the budget are very nebulous. They list lots of things, but there is no indication of any planned thrust.

I think the Nation and the young people of this country and those of us who have struggled to teach over all these years are entitled to a bit more leadership.

I consider that the curriculum in chemistry at the precollege level is rather good for the student that has made a professional commitment and will require chemistry to develop technical competence for a professional goal; but that it is nonexistent, essentially—that is not literally true, of course—but it is very, very inappropriate in most schools or places for those people who will be a part of the technological and scientific society but will in fact acquire no competency to understand the issues sufficiently to participate in the value judgments that have to be made that will determine the direction and rate of growth, of expansion, of scientific and technological knowledge, and also will determine the direction and rate of development of technology.

The curriculum in chemistry—and that is the one I will talk about—is just so completely inadequate. Now, there are things that the States can do. There are things that individuals can do. My preference would be for the National Science Foundation to develop programs particularly in this area.

Mr. GREGG. Could you give me an example? I am not sure I am understanding, theoretically, what you are saying.

Dr. HARRISON. All right. If you look at the number of students that elect to take chemistry in high school, it is a very small percentage. My personal feeling is that the judgment of the children may be rather good in that what goes on in the classroom in chemistry is not very appropriate for their capabilities or their interests. That is, we have a curriculum that was developed following the Sputnik years to prepare professional scientists. It is not the appropriate curriculum for the great majority of young people that are in the schools.

Mr. GREGG. We should teach them how to make wine?

Dr. HARRISON. No, I don't think so at all.

Mr. GREGG. I am just kidding. I was thinking we might attract some more students. [Laughter.]

Dr. HARRISON. No, that is exactly the wrong approach, and it has been tried.

I can give you my priority list of the things that I would like a young person to come out of the high school knowing, if you would like to know.

Mr. GREGG. Yes, please.

Dr. HARRISON. All right.

I would like for them to have the opportunity to discover phenomena. I would like for them to have the opportunity to investigate phenomena, to understand through the process of doing it something about the process of investigation, which is the basis of the scientific knowledge.

I would like for them to discover that they can understand things that have to do with science. I would like for them to discover that they enjoy doing it. I would like for them to discover that they can extend their own knowledge in science outside the classroom, and the pious prayer is that they will spend the next six decades doing this at least at the level of the mass media, and the mass media is getting good; it will get better.

Mr. GREGG. Thank you. That does explain your answer very well.

Dr. Rosenzweig, you mentioned in your summary here, and you discussed it earlier, but can you go over it again? You say you feel science is—that we are starting to take the Russian approach where we take a political position and then we move onto science. Can you be more specific on that?

Mr. ROSENZWEIG. Well, that was perhaps an exaggerated metaphor, but you can take it as a metaphor rather than an exact parallel.

There are real problems with introducing politics into scientific judgments.

Mr. GREGG. Let me set up a hypothetical for you. Today in the Congress there is a tremendous reaction to the need for math and science education in the school systems. Is it inappropriate for the Congress to aggressively pursue that?

Mr. ROSENZWEIG. No.

Mr. GREGG. That is not the type of example you are talking about regarding politicizing?

Mr. ROSENZWEIG. No. That is correct. It would be inappropriate for the Congress to designate who should do it, who should do the work and what the nature of the work ought to be. That would be inappropriate.

Mr. GREGG. Well, when we fund it, how do we fund it if we don't designate somebody to use the money?

Mr. ROSENZWEIG. You generally fund by categories of expenditure rather than by specific projects——

Mr. GREGG. Oh, I see.

Mr. ROSENZWEIG [continuing]. Unless the projects are very large indeed, like nuclear accelerators and so on.

Mr. GREGG. So you are talking about us putting our finger on the specific application of the money. Is that what you are saying?

Mr. ROSENZWEIG. Yes, that is correct.

Mr. GREGG. Then, would you have resisted our decision to kill Clinch River?

Mr. ROSENZWEIG. I don't consider that a scientific enterprise. Whatever else it was——

Mr. GREGG. You should have been here earlier. [Laughter.]

Mr. WALGREN. Will the gentleman yield?

Mr. GREGG. Yes.

Mr. WALGREN. Wouldn't, though, the most important things not to fund directly be the very large projects? On the one hand, they soak up all the money, and on the other hand, they are the result of a very specific assembly of interests and attention that might be way off the scientific mark. So why shouldn't the scientific community drive that selection?

Mr. ROSENZWEIG. I think Congress does best at questions of resource allocation and that specific decisions of a scientific character—that is, deciding whether this project is more scientifically desirable than that project, or that this piece of science ought to be done rather than that particular piece of science—you may get it right by accident, but over the long run, you are going to be using the wrong criteria and therefore, more often than not, reach the wrong decisions.

I don't mean at all to read the Congress or representative institutions out of the process of scientific policymaking. I think, though, that the decisions about who ought to do science, where it ought to be done, and how it breaks down in its fine structure are corrupted—I think I would use that word—are corrupted when they are mixed with questions of ideology on the one hand or constituency considerations on the other hand.

Mr. GREGG. You can say that about a lot of things, including defense.

Thank you, Mr. Chairman.

Mr. WALGREN. The hearing opened with Mr. Sensenbrenner making a rather impassioned plea for similar purity and avoiding the corruption and whatnot.

You indicated, Dr. Rosenzweig, in your testimony that we stopped investing in science in the late 1960's. As I understand, one of the things we stopped, one of the largest things we stopped, was some of the actual construction of facilities, physical buildings and the like.

As I understand the motivation of Mr. Sensenbrenner and others, it is to react to an allocation of money for physical buildings and construction in a specific set of circumstances. It has been my experience that those were always—well, I don't know how you make the decision of who gets what in terms of physical buildings. The previous programs were attempting to address a deficiency.

It strikes me that we have talked here today about how these things come down to a political decision at some point, and it seems to be inconsistent to hail the previous bricks-and-mortar programs and then point to a present bricks-and-mortar project as corrupting the system in some way.

Mr. ROSENZWEIG. I am not opposed to politics. I am a political scientist, after all. If I were opposed to politics, I quess I would have to get into some other line of work. I am opposed to its application in inappropriate ways and at inappropriate points in the process.

In fact, the decisions about where to put research facilities are, in general, not fundamentally different from the decisions about what research to support, because they are in essence the same decision. You decide to build a research facility or fund a research facility because of a judgment that somebody makes that what is going to go on in there is going to be worth doing, and that, I submit, is primarily a scientific judgment, not a political judgment, or ought to be primarily a scientific judgment, not a political judgment.

I think, by and large, making allowances for the fact that there are human beings all over the place and that we are all frail mortals and that we all do things that we know we shouldn't do sometimes, but we do them anyway, by and large, we have been very good about making those decisions on the basis of the best judgments we are able to muster about the quality of the science that is going to be done.

It simply is not the case that the previous facilities programs that were run in the fifties and sixties were rampant with political judgments and political influence. There is lots of evidence to the contrary. Even though one can find instances of political influence in this case or in that case, we have been very good about resisting that on the whole, and I think it would be really tragic for our scientific effort if we were to stop resisting that now because there seemed to be reasons of expediency for doing it differently at the moment.

Mr. WALGREN. Are there other questions or thoughts?

[No response.]

Mr. WALGREN. On behalf of the committee, let me thank both of you. We appreciate your being a resource to us, and we appreciate your testimony very much.

Dr. ROSENZWEIG. Thank you very much.

Mr. WALGREN. With that, let me invite the second two witnesses to come forward, Dr. Russell Drew, representing the Institute of Electrical and Electronic Engineers, and Dr. Henry Aaron, testifying on behalf of the Consortium of Social Science Associations.

Dr. Drew, welcome. Dr. Aaron, we are glad you are here. Let me again say that written statements will be made part of the record automatically, and please feel free to summarize or otherwise focus your comments on points that you believe particularly need to be emphasized and made.

Let's start with Dr. Drew.

[A biographical sketch of Dr. Drew follows:]

DR. RUSSELL DREW

Dr. Drew received his Bachelor's degree in Engineering Physics from the University of Colorado in 1953 and his Ph.D. in Physics from Duke University in 1961. From 1976 to 1977, he served as the Assistant Director for National Security Affairs of the Office of Science and Technology Policy, Executive Office of the President. He was Director of the Science and Technology Policy Office at the National Science Foundation from 1973 to 1976 and was a Senior Staff Assistant in the Office of Science and Technology from 1965 to 1972. He is currently President of Viking Instruments Corporation, a small business involved with development of scientific instruments and technical consulting services.

Dr. Drew is Vice President, Professional Activities and Chairman of the United States Activities Board of the IEEE and has chaired the IEEE Technology Policy Conference held in Washington, D.C. Dr. Drew specializes in Science and Technology Policy matters and application of technology to advanced instrumentation.

STATEMENT OF DR. RUSSELL C. DREW, VICE PRESIDENT FOR PROFESSIONAL ACTIVITIES, INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS

Dr. DREW. Thank you, Mr. Chairman.

I will summarize my remarks and address in that process some of the issues and the points that were raised in the earlier discussion that you had this afternoon.

I am here today representing the Institute of Electrical and Electronics Engineers. It is the world's largest technical professional society. We have over 250,000 members worldwide, and about 200,000 of those members live and work in the United States.

I should point out also that the testimony was coodinated with the Public Affairs Council of the American Association of Engineering Societies, a group of the major engineering societies in the United States. The membership of that group includes civil, mechanical, electrical, chemical, and other branches of engineering, with a total combined membership of something over 500,000 U.S. engineers.

Mr. Chairman, I would like to put the discussion today about the National Science Foundation's role in some context. I think it is relevant both to the dollar amounts that have been requested for engineering, the increases that have been commented on, and on some question of where we are going with engineering support from the Foundation and from other places in the Federal Government.

It hasn't been very long since engineering—in fact, if you look at one of the tables that was provided to illustrate the area where there has been some significant growth—where all of the engineering support provided by the National Science Foundation was about equivalent to one item, one small fraction, of the biological, behavioral, and social sciences; that is, it was about $75 million, which turns out was the amount given to physiology, cellular, and molecular biology in this table.

When you consider the very important integrated role that engineering plays in the spectrum of activities that goes from very fundamental investigations at one end of the spectrum to the engineering application/product development orientation of engineering in industry, you recognize there was a very strong disconnect, particularly at that time, between our national needs and our national priorities for this capability. I like the term problem solving; I think that is exactly what we are talking about. We had some very big problems, and we continue to have them, with product development, with quality control, with the development of new items, new goods and services that will keep U.S. industry competitive in an increasingly competitive world marketplace.

So we see the growth in engineering support within the National Science Foundation as entirely warranted; that, in fact, it is an absolutely necessary part of the Government's role to improve our stature technologically throughout the world and to assist in improving our industrial competitiveness.

It is therefore in that context that as we look at the increase proposed for engineering this year, we look back on the base on which we are building. It is, I think, still fair to point out that of the four major research directorates, engineering is by far the smallest, by over $100 million.

Now, what we are illustrating here is that percentage growth rates, while they give you an indication, must also be looked on in the context of the total dollar amount that is involved. Engineering is building on a very small base, and we believe that it is important to recognize that this is a very small base within the NSF program.

The bill which you have considered and which was discussed earlier, H.R. 4822, addresses the explicit recognition of engineering within the National Science Foundation charter. Mr. Chairman, I would like to point out that as we looked at that charter, we found out that engineering has already been singled out within the bill, and that it was done in a way which talked in terms of engineering sciences.

Now, the National Science Foundation Act was prepared, was drafted, in the immediate post-World War II years, largely as the result of Vannevar Bush's very prescient report, "Science, the Endless Frontier."

Now, during that period, the sciences—and I think the language that was used during that period reflected it—the sciences were considered as including engineering.

With the passage of time, however, we found that there seems to be a much stronger distinction between engineering and science. Therefore, we in the IEEE support the explicit recognition of this distinction which has been increasingly made in society as a whole of a rather special role which we call engineering, and particularly a role in support of engineering research within the National Science Foundation's total assigned objectives.

We think it recognizes, in a very important way, this shared responsibility, which I think has been there and certainly has been part of the way the NSF has attempted to respond to this concern about engineering over the past few years. But we also think it is useful to recognize it explicitly.

I should say a few words about engineering research. We support the budget increase. In fact, as we look at the needs in engineering research, we believe that even further increases are warranted and desirable.

Engineering research has multiple benefits. It will provide the challenging assignments that graduate students and professors will be working on in the educational environment in our colleges and universities.

It is quite often felt by many people that engineers tend to, if you will, leave after their first 4 years in college. It is certainly true that for a majority of engineers this is the case—but if you look at the NSF data on master's degrees, you find that the one field with the largest number of master's degrees in all science and engineering fields is engineering which stands out as ahead of social sciences, physical sciences, mathematics, or life sciences. There are more in engineering.

The people that are getting these degrees should have a challenging research environment as part of that educational experience. You could also look at the same sort of relationship in terms of Ph.D.'s. The research environment in engineering is as important to the engineering fields as the research environment is to the fields of science.

It improves the quality of the educational process. It improves the quality of the engineers which are going to be produced by our educational system. It will reflect back positively into the first 4 years of education, where a large fraction of the engineers leave their formal educational programs and go out into industry.

And so we see this investigator-originated research support by the National Science Foundation as a very important part of the Federal Government role in basic research overall.

When you look across all other agencies—and I think it is important to do this, to understand what share of this research support NSF bears—engineering is, if you look at just research funding, about 11 percent of the NSF research total. Well, when you take all Federal research for science and engineering, you find out that engineering is about 11 percent, so that the NSF fraction is about what it is for the Government as a whole.

The point here is that there is not some other agency like Defense or NASA that is picking up the slack for engineering. In fact, the NSF is equally important in terms of engineering research as these other agencies.

Let me add just one final comment. The IEEE sponsored a technology policy conference here in Washington this week. We had a number of speakers from Government. The chairman, Mr. Walgren, was one of our featured speakers, and we are very happy that you were able to speak to our members. There was an interesting thread that emerged from industry, Government, and academia during that week, and that was the importance of the human resource.

The human resource in the field of engineering is going to depend upon the quality of the educational experience. That high-quality educational experience is something that we believe the NSF has a very specific and unique and special role in developing and encouraging. For that reason, we see the role that they are playing in this research arena as an integral part of improving the human resource potential as well as extending the body of knowledge, and for that reason we support very strongly this increased NSF role and, in fact, further increases to improve the situation for engineering in the United States today.

That concludes my remarks, Mr. Chairman.

[The prepared statement of Dr. Drew follows:]

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STATEMENT TO THE
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

by

DR. RUSSELL C. DREW

on the Authorizations
for the National Science Foundation
for FY 1985

FEBRUARY 28, 1984

MR. CHAIRMAN:

It is a pleasure to have this opportunity to testify before you today on the proposed NSF Budget for FY 1985. My name is Russell Drew and I serve as the Vice President for Professional Activities and Chairman of the United States Activities Board of the Institute of Electrical and Electronics Engineers (IEEE). Today I also have the privilege of presenting views that have been coordinated with other members of the engineering community through the Public Affairs Council of the American Association of Engineering Societies (AAES).

The IEEE is the world's largest technical professional society with about 250,000 members world-wide, of which more than 200,000 live and work in the United States. Altogether, the sixteen engineering societies that are members of the AAES, including the IEEE, have a combined membership of over one half million. The relative priority given to engineering needs by the National Science Foundation and the status of engineering within the Foundation are matters of great concern to our members.

Therefore, before treating specific individual items of this budget proposal before you today, I would like to cover some of the background that lies behind our remarks. This will help you to understand our views on changes in program emphasis in a larger context.

Although a great majority of engineers are in industry---indeed, they are the technical resource that makes possible the growth in high technology industry in the United States today---these engineers are sensitive to the university environment in which new engineers are being produced and to the importance of engineering research to our national industrial competitiveness. Because of these concerns, in the past few years, the engineering community has given special attention to the role of engineering research in helping to create a more dynamic environment for engineering education in our colleges and universities. Such research has multiple positive effects: it helps to keep the faculty at the cutting edge of their disciplines, it provides challenging targets for engineering graduate students to sharpen their skills and to prepare for future roles either as engineering faculty or elsewhere in the engineering community, it makes a contribution to the advancement of the state of knowledge in engineering fields, and it lays the foundation for improvements in the undergraduate education of engineers. Such research is therefore as important to the fields of engineering as the scientific research supported by the NSF is to the various scientific disciplines.

We believe that the foundation for our future economic health is in our human resources, the skilled engineers and scientists that our educational system is capable of producing if given adequate help and support from Government. But beyond those who are actively engaged in technological enterprises, in this technological age we must also be concerned about the general state of knowledge in mathematics and science that the average citizen possesses, if we are to have an informed population and a society capable of coping with the challenges that technological changes bring. Thus, we strongly support those programs within the NSF which address these needs.

On a broader front, the engineering community has been supportive of the new emphasis within the Foundation on engineering and on the increasing research support for the engineering disciplines. We have been encouraged by the gradual emergence of an Engineering Directorate, and we hope to see this directorate have an equivalent stature and status within the NSF structure as the scientific directorates. The National Science Board has also become sensitive to the need for greater engineering emphasis--- all signs that our message is being heard. It is disappointing, therefore that the appointment of an Assistant Director for the Engineering Directorate has been delayed for more than five months. At a time when there is discussion of new initiatives in engineering it is particularly unfortunate not to have a permanent Assistant Director, well-recognized in the engineering community, to provide leadership for this effort. Indeed, it would appear desirable to have this position recognized for its importance by having it designated as a Presidential appointment, confirmed by the Senate.

This Committee has recently been presented with legislation, H.R. 4822, that would accomplish this as well as modify the basic statuatory authority for the NSF to include additional references to engineering throughout the basic organic act. Mr. Chairman, let me emphasize that we in the IEEE see a need to continue the process of strengthening engineering in the NSF. Such strengthening is essential if we as a nation are to be equipped to respond effectively to the challenges to our industrial competitiveness that have been raised by other nations. We believe that Congress should go on record to this effect to indicate to the Administration and to the Foundation leadership that further progress is needed and expected. This is our primary concern and objective. It should be understood that we do not support increased emphasis on engineering at the expense of the traditional strong support of science by the NSF.

The proposed change in the organic act for NSF described in H.R. 4822, is consistent with our concerns and we support it in principle. When the National Science Foundation Act was originally drafted more than 35 years ago, the term "sciences" quite often was used as a generic term that included engineering. Thus, phrases appear in the Act that refer to "...the engineering...and other sciences" (emphasis added). With the passage of time, language usage changes and today there is a much stronger distinction between the term "science" and the term "engineering". Therefore we believe it may be useful to clarify this point in the NSF Act and thereby reinforce the positive direction that has been taken by the NSF.

There are specific provisions of H.R. 4822 that we believe need modification. In particular, the increase in size of the National Science Board from 24 to 36 members appears undesirable. Such a large body become unwieldly and is likely to loose its effectiveness. However, we do believe that there should always be engineering representation on the Board and that the National Academy of Engineering as well as the engineering societies should be consulted for possible candidates to fill appointments to the Board whenever they occur.

Let me now proceed to more specific comments on line items in the NSF budget submission.

ENGINEERING RESEARCH

The total funding for Engineering is proposed to increase by

$26.4 million in FY 1985, or only 14.6% of the $179.8 million increase that is proposed for the Foundation. In our view this is not an adequate reflection of the priority that is needed for engineering research, which has been consistently underfunded by the NSF. In addition, it should be pointed out that this increase is reduced by the effects of several targeted programs, which are included in the total because of the way that NSF now presents its budget.

Let me illustrate how these targeted programs impact the research programs that are of concern to us. Over the past few years, there have been several new initiatives in the NSF such as the Presidential Young Investigators program, support for scientific and engineering equipment, industry-university cooperative research, and more recently the supercomputer program, Engineering Research Centers, and support for predominantly undergraduate institutions, the funds for which are now being included as part of the total funding for engineering research. These targeted programs are laudable and we support their objectives. However, the consequence of forcing the funds for these new programs to be absorbed within the regular research funding totals places an inordinate burden upon the Engineering Directorate because of the much smaller base in comparison with the other much larger research directorates. Thus, when these targeted programs are taken into account the total funding left for engineering research objectives is almost level with last year (including the effects of inflation). In our view this does not show adequate recognition of the national need to strengthen the engineering enterprise nor does it reflect the emphasis that NSF claims to be giving to this area.

The important missing element is an increase for individual investigator research awards that are available to the broader engineering faculty, in addition to the small number of individuals who will be honored with Presidential Young Investigator awards. It is this base of individual investigator awards that has been eroded with the addition of the new targeted programs as well as by the effects of inflation.

Therefore, we strongly recommend additional funding for the Engineering Directorate, to be devoted to individual investigator programs. This funding is needed to restore a modest degree of growth to an area that is of vital importance to the nation and to our international competitiveness.

In the targeted areas, the new initiative that is proposed involving the establishment of Engineering Research Centers for Cross-Disciplinary Research is noteworthy. This recognizes that a growing number of problems of both academic and industrial interest require the efforts of multi-disciplinary teams, and that such cross-disciplinary work needs to be supported as a new research emphasis in the university environment. It is appropriate to structure such efforts in new centers since this will highlight the need to think about innovative ways of addressing these problems outside of the traditional discipline-oriented approaches. Accordingly, we support the full amount, $10 million, for this new program.

One of the smaller of the targeted programs is the International Cooperative Research Activities, which is budgeted at $11.8 million for 1985. Of this amount, $5.0 million is in the Directorate for Scientific, Technological and International Affairs and the remainder is distributed within the research directorates. This type of program activity is under-appreciated and underfunded, particularly in the engineering disciplines. It provides an opportunity for investigators in the U.S. to take advantage of expertise beyond our borders in dealing with common problems or to perform experiments in locations and settings that would not otherwise be available to us. At a time when there is increasing call for U.S. assistance to our neighbors in the Caribbean and Central America, with many millions devoted to aid of various kinds, the type of mutual cooperation possible in the research programs sponsored by the NSF are a refreshing contrast. In these programs, with their encouragement for the expansion of local capability in the region, the U.S. can have greater effect at lower cost than some of the more visible programs. *We recommend an additional allocation of $3.0 million for a targeted program in Central America and the Caribbean, to be added to the research activity budget.* The authorities in the region have proposed the formation of a Caribbean Academy of Science and Engineering, which could be a focal point for such cooperative efforts.

Another targeted program, the Presidential Young Investigators awards, will be moving into its second year. There is a large fraction of this program that is included in the Engineering Directorate in an effort to provide more incentive for new engineering faculty at our engineering schools. We support continuation of this program. We also note that there is a very similar program that has been utilized by the Engineering Directorate for a number of years called the Research Initiation Grants. These grants also need to be maintained and extended as another option for bringing junior faculty members into active research roles. The Presidential Young Investigators program does not replace these Research Initiation Grants, both of which must be funded out of the Engineering Directorate total.

ENGINEERING EDUCATION

Mr. Chairman, I would now like to move from research to the field of engineering education. In the NSF this year as last, the support for engineering education is restricted to indirect measures such as graduate fellowships or as a by-product of one of the research-oriented programs that I have already covered. While these are welcome, there is no substantial effort that directly addresses undergraduate engineering education.

On the other hand, there is a program for pre-college improvement in science and mathematics. This is a problem area that has received considerable attention recently and we in the engineering community applaud the efforts that have begun both in Government and in the private sector to address this national problem. We are particularly sensitive to this issue and will be devoting our own efforts as professional societies to assist in improving the current situation. This is a large issue and has been many years in developing, so quick fixes are not available. It will take concerted effort at the local level over a number of years to redress the years of neglect, and the assistance of the Federal Government will be a welcome partner in this effort. We support the proposed budget of $34.7 million for pre-college teacher improvement in science and mathematics. in connection with other measures to assist in dealing with this problem.

In this context, the lack of substantial support for undergraduate engineering education programs is most unfortunate. Unlike undergraduate education in science, the undergraduate program in engineering is one which, for the great majority of engineers is the end of their formal, full-time educational development. The U.S. industrial community where more than 3/4 of U.S. engineers are employed is completely dependent upon the quality and quantity of the available baccalaureate degree recipients. The quality of their educational experience has with few exceptions been decreasing as engineering schools have been unable to fill their faculty vacancies or keep their instructional laboratories equipped with state-of-the-art instrumentation. Because of the intimate relationship of the educational and research programs in U.S. engineering schools, the Engineering Directorate of the NSF should be assigned the responsibility of determining what steps should be taken to strengthen these programs. They should be asked to provide the Congress specific recommendations and an implementing program to strengthen and update undergraduate engineering education in the United States.

At this time of widespread concern over budget deficits, it may seem presumptuous to come before this committee with the requests for additional support that have been outlined above. However, it is our belief that such investments are vital to our economic health since it is engineering and engineers that will provide the critical linkages between scientific discoveries in the laboratory and products and services in the marketplace.

The U.S. cannot afford to risk the consequences of ignoring these needs.

Mr. Chairman, this concludes my remarks on the NSF budget. I have also prepared comments upon the budget for the National Bureau of Standards that I am requesting be placed in the record. I will be pleased to answer any questions you may have.

Mr. **Walgren**. Thank you, Dr. Drew. We appreciate that. Let's turn to Dr. Aaron and then come back for questions.

[The biographical sketch of Dr. Aaron follows:]

RESUME OF HENRY AARON, Ph.D.

Education

Ph.D.	Economics, Harvard University, 1963
M.A.	Russian Regional Studies, Harvard University, 1960
B.A.	Political Science & Economics, UCLA, 1958

Current Activities

Senior Fellow, The Brookings Institution, 1968-1977; 1978-present.

Professor of Economics, University of Maryland, 1974-1977; 1979 - present; Associate Professor, 1967-1974.

Member, Commission on Behavioral and Social Sciences and Education, National Research Council, 1983 - present.

Member, Board of Directors, Consortium of Social Science Associations, 1982 - present.

Government Experience

Assistant Secretary for Planning and Evaluation, Department of Health, Education, and Welfare, January 1977 - December 1978.

Chairman, Advisory Council on Social Security, 1978-1979.

Chairman, Panel on the Housing Allowance Experiments, Department of Housing and Urban Development, 1975-1977.

Member, Urban Policy Working Group, Department of Housing and Urban Development, 1979-1980.

Member, Council of Economic Advisers, State of Maryland, 1969-1975.

Senior Staff Economist, The Council of Economic Advisers, July 1966 - June 1967.

In addition, Dr. Aaron has taught at several universities and served on numerous advisory boards and committees. He is the author of many books and articles on topics such as taxation, welfare, social security, and housing. His most recent book is The Painful Prescription: Rationing Hospital Care (co-authored with William B. Schwartz, Brookings, 1984).

STATEMENT OF DR. HENRY AARON, MEMBER, BOARD OF DIRECTORS, CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS

Mr. AARON. Let me begin by saying that I am here today not as a staff member of the Brookings Institution or a professor at the University of Maryland, but as a member of the executive committee of the Consortium of Social Science Associations, COSSA, a group of organizations that contain a membership of about 175,000 social scientists in various fields.

I have been asked to comment on a number of issues, on only some of which does COSSA have an actual position. But there are some additional points that we would like to make as well.

To begin with, we want to express our approval and support for the proposed budget increase of 13.6 percent in the funding for the social science areas. It is such a good idea, we think it could be made even better along lines I will suggest in a minute.

The reasons, I think, are similar to ones you have heard before, I have no doubt. Continued research support in this area, both for the carrying out of research, for the development of data and for training and education, produce very great benefits for the society at large. We feel that the record amply shows that it would be false economy to try to stint in this area, as in fact was done in the years from 1981 to 1983.

We are grateful for the efforts that this subcommittee has made in the past. Our membership is aware of this effort in trying to maintain an adequate level of funding for social science research, and we appreciate it.

In our testimony, we have attached a pair of tables that I think place in some perspective what has been going on with respect to both social science and behavioral science research as against the background of the rest of NSF activities.

Like every table of budget numbers, these are actual dollars; they are not inflation adjusted. I will have a word or two to say about that.

As you can see, from the period from 1980 to 1985, the budget for social and behavioral science programs is down 10 percent without adjustment for inflation. Those cuts are not nearly so deep as were requested by the administration, in significant measure because of your own efforts. Nonetheless, the contrast of that figure with the rest of what has gone on in the National Science Foundation is fairly stark.

We are not here to suggest that research in other areas was not very important. We are here to suggest, however, that the reduction by nearly half in social science funding that occurred between 1980 and 1982, which virtually eliminated new research starts by the National Science Foundation in many fields, does not correspond in any way to the importance priorities of the problems that were being addressed by social science research.

We note that a significant proportion of the budget for the biological, behavioral, and social sciences is earmarked for support of large-scale data bases, and in this area we want to also lend our support. It is vital that analysts, researchers in all fields have solid information on which to carry out their research, and we feel that this is a desirable step in the right direction.

It is also vital that there be scientists trained and adequately funded to carry out analysis on the data that are collected in this and other forms; otherwise, the data are not put to their proper use.

To put the cuts that have occurred in the past in some context, between 1980 and 1982, the real outlays on social and behavioral science programs fell by about half. The share in total NSF funding dropped from 5.9 percent to just a little over 3 percent. There has been some recovery in recent years, but it is important to understand that after adjustment for inflation, real spending in this area is about one-third lower than it was 5 years ago.

Now, what are the effects of these cuts? How important are they and have they been? The principal consequence has been that there has been an extraordinarily serious decline in the number of individually executed research projects, which really are the seedbed for development of basic scientific knowledge and for the training of the new generation of scientists.

The ambitiousness of research projects has been trimmed back, and shortrun projects have pushed out others that have greater longrun promise but do in fact carry more risks.

The importance of social science research, is best understood against the background of the types of problems that are being addressed by investigators in these areas, and the types of problems that our Nation faces.

The previous two witnesses correctly observed that social science isn't going to spoon-feed to the society easy answers to hard problems. There is no doubt that that warning is correct and that one is letting oneself in for a grievous disappointment if one looks to social scientists to do what society at large does not have the will to do.

Nonetheless, if you think about the social, economic, and political problems that the Nation faces today, there is a remarkable parallelism and a remarkable payoff to successful social science research.

For example, we face a productivity slowdown. This isn't just a problem of competitiveness that has been exacerbated by the appreciation of the dollar. For 10 or 15 years, growth of U.S. productivity has been declining markedly.

And yet at the same time social scientists are trying to carry out research on worker productivity, on quality control, and we have a record where some of this research has produced results that have been effective in linking new methods of management to increased productivity.

We are in the process, and have been for a number of years, of deregulating massive sectors of the U.S. economy involving tens of billions of dollars of investment and millions of jobs. Surely it makes sense to invest adequate funds in monitoring what is going on and measuring whether this grand social experiment has been a success or not.

Reference has been made by previous witnesses to the lag in performance of American students in science and mathematics. This is not just a problem for the hard scientists; it is a problem for educators and psychologists. It is a problem for people who study memory and cognition and who study teaching methods and how learning is carried out. That is the heartland of certain of the social sciences. Can we afford to neglect these areas at the present time?

The courts and the marketplace have been carrying out another social experiment on the degree to which wage differences between men and women and between other groups are merited or are not merited by differences in productivity and what the consequences are in terms of our social relations.

Are we to make these decisions bereft of data and analyses that might enable us to compare individuals with similar experience and training and sort out the degree to which differences in remuneration reflect real differences in productivity or reflect caprice and discrimination?

I mention these areas not as an exhaustive list but simply to illustrate that there is a very close match-up between the agenda of the social sciences and America's agenda in the 1980's. For that reason, it is vitally important that we set as an interim goal bringing back to the 1980 level the funding of research in the social and behavioral sciences by the National Science Foundation.

The proposal for 1984 is a beginning, but it only takes us part of the way there. We would urge that you give the most serious consideration to accelerating that timetable and trying to get us back to the level of funding that existed in 1980.

Note that we are not asking for the real increases that mark the rest of the National Science Foundation budget. We are simply asking that the level of funding be restored to the 1980 level at the earliest possible date.

I have made no explicit comment, and COSSA does not have any position, on the issue of the reorganization within NSF concerning particular branches of applied research.

At this point I think the best thing I could do would be to stop and, along with my colleague, be ready to receive any questions you may have.

[The prepared statement of Dr. Aaron follows:]

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TESTIMONY OF DR. HENRY AARON

A statement prepared on behalf of the
Consortium of Social Science Associations

on the

FY 1985 BUDGET FOR THE NATIONAL SCIENCE FOUNDATION

Prepared for the

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

The Honorable Doug Walgren, Chairman

February 28, 1984

American Anthropological Association • American Economic Association • American Historical Association • American Political Science Association
American Psychological Association • American Sociological Association • American Statistical Association
Association of American Geographers • Association of American Law Schools • Linguistic Society of America

My name is Henry Aaron.

A biographical statement is attached. I am testifying today on behalf of the Consortium of Social Science Associations (COSSA), an umbrella organization that represents 175,000 social and behavioral scientists across the social science disciplines. A list of COSSA Members, Affiliates, and Contributors is attached to my testimony.

I have been asked to comment on several issues: the overall budget request for the National Science Foundation (NSF) for FY 1985; the organizational structure within NSF for dealing with cross-cutting issues; and the NSF Experimental Program to Stimulate Competitive Research. I will also testify at greater length on the FY 1985 budget requests for the social and behavioral science programs at NSF.

COSSA is pleased that the National Science Foundation will receive a budget increase of 13.6% for FY 1985. Despite the severe constraints on the FY 1985 budget imposed by the size of the federal deficit, it is important to maintain the nation's investment in basic research. Without such continuing investment, the United States would become steadily less able to compete with other nations economically, the quality of our science and inventiveness of our technology would decline, and we would weaken the flexibility of our economy in the future.

I do not feel qualified to comment on the NSF Experimental Program to Stimulate Competitive Research or on the management structure for dealing with cross-cutting issues at the Foundation. I would, however, like to comment on the content of the NSF program in one cross-cutting area, that of computers.

When the Director of the Foundation, Dr. Edward Knapp, testified before this Subcommittee on February 9, he discussed NSF plans for advancing the state-of-the-art in scientific computing facilities. Among the research areas he singled out for mention was the need of the social sciences for computers. I would like to underscore that need. Social science data sets are exceedingly complex. They require sophisticated computing equipment that can handle large bodies of data and complicated multivariate modeling and econometric procedures.

I will turn now to the question of budget levels for NSF research programs in the social and behavioral sciences. Members of this Subcommittee do not need to be reminded of the major cuts in NSF budgets for the social and behavioral sciences in FY 1981 and FY 1982.

As serious as these cuts were, they were not as deep as those requested by the administration. In large part this was due to the efforts of this Subcommittee. This Subcommittee has constantly sought to restore funds to these programs that the administration tried to cut. In addition, Members of the Subcommittee from both the majority and the minority have spoken out in favor of restoring funds to the social and behavioral sciences during floor debates on the NSF appropriation. Social and behavioral scientists appreciate this support.

In FY 1985, the budgets of the social and behavioral science research programs in the Directorate for Biological, Behavioral, and Social Sciences (BBS) are scheduled for an overall budget increase of 10%, principally for support of the large scale data bases. This is an important and necessary emphasis. These data bases have suffered from the budget cuts over the past several years. They are expensive, yet they cannot be postponed until budgets are increased again. If a survey -- such as the National Election Study (NES), or the General Social Survey (GSS) -- cannot be conducted at the required time, its scientific value is impaired. The FY 1985 funding provided for the social and behavioral science programs in the BBS budget will relieve some of the funding pressures on these data bases.

Despite the proposed 10% increase in FY 1985 for the social and behavioral sciences as a whole, they will still be funded at a level that is 10% below their FY 1980 level -- even without taking inflation into account. If we calculate the effects of inflation, the proposed level for FY 1985 is 31% lower than the FY 1980 level. The share of NSF spending devoted to the social and behavioral science programs falls from 5.9% to 3.3% between 1980 and 1982 and will rise under the administration's request only to 3.6%, a drop of 40% in the share of the social and behavioral sciences in NSF spending. Two charts with these and other NSF budget figures are attached to my testimony, and I request that they be printed in the hearing record.

We face a situation in which the social and behavioral sciences are now receiving budget increases that would be adequate had outlays not been slashed so deeply in 1981 and 1982. But those cuts did occur and should not be allowed to stand.

The consequences of these cuts are most apparent in the decline of single investigator projects, the seed-bed of social science research and training. The effects of this false economy are predictable and pernicious. Proposals are whittled down and stretched out to spread available funding, thereby causing delays in research and reductions in training. Scientifically ambitious investigations are jettisoned for less ambitious projects that can be accomplished less expensively. A strong research system requires not only the development and maintenance of good data bases, but also the support of established scholars and training for their successors. The support that is provided this year for the large scale data bases is a step in the right direction. An important next step is to increase support for individual investigator projects.

We realize that Congress must scrutinize every appropriation this year to see if the nation can afford it. In answer to that question, we urge you to look at developments in basic research in the social and behavioral sciences. This is what the National Academy of

Sciences/National Research Council did recently. The report of that investigation, entitled Behavioral and Social Science Research: A National Resource, describes and strongly endorses the scientific advances that have taken place in the social and behavioral sciences in recent years.

Another way to consider the question of increased support for social and behavioral science research at NSF is to examine some of the problems we face as a nation and the research that is conducted by social and behavioral scientists.

For example, we face a slow-down in productivity growth. Social and behavioral scientists conduct research on worker productivity and management efficiency. Social science experiments on worker productivity and quality control have led to effective techniques for linking participative decision-making and the acceptance of innovations in the workplace.

We are deregulating many branches of the economy. Hundreds of billions of dollars of investment and tens of millions of jobs are involved. Surely the investment of a few million dollars in the study of the effects of this monumental social and economic experiment is only prudent.

Newspapers report on the lag in performance of U.S. students in science and mathematics relative to students in other countries. Can we afford to curtail social and behavioral science research on memory and cognition, teaching and learning?

We face continuing problems in the courts and in the marketplace with the issue of whether wage differences between men and women are based on sex or on experience, skills, performance, or other factors. Do we wish to make decisions in these areas bereft of data and research that would enable us to compare individuals with similar experience and training and sort out the various influences on income?

The basic research in all these and many other areas has been supported by NSF in the past and we respectfully suggest that additional work is needed now.

We recognize the budget problems created for the Congress by the size of the federal deficit. However, we think that on policy grounds and on substantive grounds, the Subcommittee should establish the goal of returning the social and behavioral science programs in the National Science Foundation to their FY 1980 levels in constant dollars. We realize that this may take time, but feel strongly that the goal must be set.

If, therefore, the Subcommittee increases the authorization level for NSF's Research and Related Activities, we ask that the increase be earmarked for social and behavioral science research. If, on the other hand, the Subcommittee decides it cannot increase the NSF research budget this year, we ask that it include in the authorization report a strong recommendation that the Foundation restore the social and behavioral science programs to their FY 1980 level in FY 1986 dollars next year.

Thank you for the opportunity to testify today. I will be happy to answer any questions you may have.

CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS

NATIONAL SCIENCE FOUNDATION

Funding for Selected Directorates and Programs (in million $)

	Actual FY80	Actual FY81	Actual FY82	Actual FY83	Actual FY84	Proposed FY85	%Change FY84-85	%Change FY80-85
Dir. for Mathematical and Physical Sciences (MPS)	227.0	256.5	272.9	299.7	359.5	416.7	+16	+84
Dir. for Astronomic/Atmospheric Earth & Ocean Sciences (AAEO)	218.1	236.3	240.0	276.2	330.3	373.5	+13	+71
Dir. for Engineering (ENG)	76.6	83.8	93.3	101.1	120.7	147.1	+22	+92
Dir. for Scientific, Technological & International Affairs (STIA)	36.6	36.0	40.3	44.1	40.8	46.9	+15	+28
Dir. for Biological, Behavioral & Social Sciences (BBS)	185.7	185.6	176.0	190.2	224.8	253.1	+13	+36
Social & Behavioral Science Programs in BBS	52.4	43.7	32.3	36.0	42.8	47.2	+10	-10
Social & Behavioral Science as Proportion of Research & Related Activities	5.9%	4.6%	3.3%	3.7%	3.8%	3.6%		
Science & Engineering Education	77.2	64.7	20.9	16.1	88.9	75.7	-15	-2

CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS

NATIONAL SCIENCE FOUNDATION (cont.)

Social and Behavioral Science Research Programs in BBS (in million $):

	Actual FY80	Actual FY81	Actual FY82	Actual FY83	Actual FY84	Proposed FY85	%Change FY84-85	%Change FY80-85
Division of Behavioral and Neural Sciences (selected programs)								
Neuroscience								
Psychobiology	4.5	4.3	3.4	3.7	4.2	4.4	+5	-2
Cognitive Science								
Memory & Cognitive Proc.	2.6	2.4	2.2	2.3	2.6	2.8	+8	+8
Social & Dev. Psychology	3.3	2.6	1.5	2.1	2.6	2.7	+4	-18
(Applied Psychology - absorbed elsewhere)	1.4	1.1	--	--	--	--		
Linguistics	2.7	2.2	2.1	2.2	2.4	2.5	+4	-7
Anthropology	6.6	6.0	5.5	5.8	6.4	6.8	+6	+3
Subtotal	21.1	18.6	14.7	16.1	18.2	19.2	+5	-9
Division of Social & Economic Science								
Economics & Geography								
Economics	12.2	9.4	6.3	7.1	9.4	10.25	+9	-16
Geography	1.6	1.2	0.7	0.8	1.0	1.3	+30	-19
Social Measurement & Analysis								
Sociology	3.9	3.0	2.2	2.4	2.95	3.65	+24	-6
Meas. Meth./Data Resources	5.0	3.9	2.9	3.3	3.6	3.4	-6	-32
History/Philosophy of Science	1.5	1.1	0.9	1.1	1.35	1.6	+19	+7
Political & Policy Sciences								
Political Science	3.6	2.9	2.1	2.3	2.8	3.6	+29	--
Law & Social Sciences	0.9	0.9	1.1*	1.2	1.4	1.7	+21	+89
Regulation & Policy Analysis	2.6	2.7	0.9	0.9	1.1	1.3	+18	-50
Decision & Management Sci.			0.5	0.8	1.0	1.2	+20	N/A
Subtotal	31.3	25.1	17.6	19.9	24.6	28.0	+14	-11
TOTAL-Social & Behavioral Science Research Programs	52.4	43.7	32.3	36.0	42.8	47.2	+10	-10

*In FY 1981, this program was combined with the Law and Policy Program of the Division of Applied Research.

CONSORTIUM OF SOCIAL SCIENCE ASSOCIATIONS

Members

American Anthropological Association
American Economic Association
American Historical Association
American Political Science Association
American Psychological Association
American Sociological Association
American Statistical Association
Association of American Geographers
Association of American Law Schools
Linguistic Society of America

Affiliates

American Association for Public Opinion Research
American Educational Research Association
Association for Asian Studies
Eastern Sociological Society
Economic History Association
Evaluation Network
Evaluation Research Society
History of Science Society
International Communication Association
International Studies Association
Law and Society Association
National Council on Family Relations
North Central Sociological Association
Northeastern Anthropological Association
Population Association of America
Regional Science Association
Rural Sociological Society
Social Science History Association
Society for American Archaeology
Society for the History of Technology
Society for Research in Child Development
Society for the Scientific Study of Religion
Society for Social Studies of Science
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University of Oregon
University of Pennsylvania
University of Pittsburgh
Princeton University
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Tulane University
University of Washington
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Mr. **Walgren**. Thank you, Dr. Aaron.

Let me recognize Mr. Brown.

Mr. **Brown**. Thank you, Mr. Chairman.

I think you gentlemen have given a much-need perspective to this business of the NSF's priorities. You have certainly given me a new perspective, both of you.

Dr. Drew, I couldn't help but think, as you described the situation that existed with regard to the relationship between science and engineering back in World War II days, the difference between that and the situation today. As I reflected on it, it seemed to me that what we saw in World War II, this vast proliferation of technological capability that we use for our defense—nuclear weapons, radar, sonar, later on lasers and a whole host of things—that what we were seeing was the triumph of engineering built upon a prewar scientific base, because most of these were situations where the science was already known, at least in embryo, and scientists were turned into engineers in order to make this scientific knowledge useful to the Nation in a time of need.

In fact, the essential discovery for nuclear weapons was Einstein's discovery, E equals MC squared, or whatever the equation was, plus the fact that others such as the Curies discovered that certain elements automatically disintegrate. Then people like Fermi found that you could artificially cause them to disintegrate by bombarding them with neutrons—that was all done in the late 1930's.

Dr. **Drew**. Hahn and Strausman in Germany did the fundamental fission measurements in about 1936.

Mr. **Brown**. Right. And it was a perception that this could be translated into a large-scale release of energy under suitable conditions that might make a weapon, and that was clearly an engineering problem.

We had great scientists like Oppenheimer and others who were told to do an engineering job—figure out how to convert this to a usable weapon as quickly as you can.

The same thing happened at MIT at the radiation lab. They took existing knowledge and used it to build new systems for discovering aircraft—radars and that sort of stuff.

What Vannevar Bush recognized after the end of World War II was that maybe we had exhausted that base of science, that rather fragile base that we had had, and that we needed to continue to build it. At that time, the distinction wasn't so clear between building that base and translating it into some usable social purpose.

It has led, over a period of a couple of generations now, to sort of an invidious distinction in which the scientists are getting all the credit for the engineering work that they did during World War II, and the engineers are not getting any credit.

The whole space program, you know, was an engineering program built upon a structure of heavy rocket boosters which the Germans developed during World War II. In effect they created tools—the engineers did—which forced science into new areas. The whole space astronomy and space exploration, which is good science, was built because the engineers created the structure on which they could do it.

Do you differ with that analysis?

Dr. **Drew**. No, Mr. Brown. I think you pointed out a fundamental frustration that is reflected in what you see as pressure from the engineering community today. That is that for many, many years the recognition has been primarily in terms of science, whereas we have seen this as a marriage, if you will, a linking between science and engineering.

Frankly, what we see here is not the need to separate science and engineering, but to recognize more strongly and more clearly the partnership that has been true in the past and we hope will continue to be true. It is just absolutely essential.

The people who set this establishment in place, however, following World War II were largely physicists and chemists, and so they thought in those terms, even though what you aptly point out is, they were doing—they were bridging that gap. They were bridging the gap between science and engineering, and there is a continuing need to recognize that function today. It is terribly important for us to do that well.

Mr. **Brown**. Yes. I think you put it very well. I would hate to have any of my physicist or chemist friends think that I am opposed to the continued success of their particular science, but I have been trying to focus on that bridging function and the fact that they cannot and should not think that the further elaboration and development of their science poses the answer to all the questions that face society.

I have a hard time convincing them that society and the taxpayers will not continue to support them if there is not a recognition of the continuous chain that exists here between the scientific development and some ultimate value to society, and it has to be more than an esoteric value of increasing our knowledge base, because while a few will appreciate that—I think I appreciate it—I don't think that the bulk of the public is going to appreciate it so as to continue funding it.

We wouldn't fund the National Institutes of Health if a lot of very selfish taxpayers didn't think their lives were going to be extended as a result. This holds true of every scientific field, and when scientists fail to recognize that they need to look at the whole picture rather than just their part of it, they are doing themselves a disservice.

Dr. **Drew**. If I may, just to add a plug for a program which I think is a particularly good program to take that bridging into the small business world, there is something called the small business innovation research program which, as you well know, is mandated in, now, 11 agencies.

The NSF is a part of that program. I think it does belong as a part of the NSF program. The NSF's perspective is slightly different than many of the other agencies. It has been my observation, however, as you point out, that the tie to an innovative society such as ours in terms of small business connections can be an excellent example of how the knowledge flow from basic research, fundamental knowledge, through application and commercializable products, is a continuum, and that in fact the NSF can play a constructive and positive role in supporting that continuum of activities. It is, I think, a very useful adjunct to the NSF research program to have that take place.

Mr. **Brown**. I am following this line of conversation not because I am trying to make any invidious points, but I am trying to help to create what you might call a pragmatic framework within which we can make political decisions that will best represent the interests of the country.

I see definite signs of change within this administration in changing their own framework, actually. I have seen numerous signs of it. But we still don't yet have a clearly enunciated, clearly understood basis on which we make these kinds of decisions.

The reason I bring up Demming, for example, is because here we have a case of where the social and behavioral sciences, integrated into a management concept, were used to bring about the kinds of economic and social changes that made the Japanese competitive vis-a-vis the United States.

We have to recognize this component of the human search for knowledge as much as we do physics and chemistry or engineering or any other. They all fit together in bringing about a total condition which is value-driven and which is basically—it involves these quality-of-life factors which were earlier mentioned by Dr. Harrison.

When we neglect one part of these and overemphasize the other, we end up with a distorted situation in which, ultimately, we fail to achieve our goals, and then we ask ourselves, what happened? This is the kind of situation that I think we should be trying to avoid in the policy decisions, the resource allocation decisions, that we make here in the Congress.

I think this is more by way of merely adding support to what both of you have said rather than to pose any serious differences with you.

I yield back the rest of my time.

Mr. **Walgren**. Thank you, Mr. Brown.

Let me ask Mr. Drew: Mr. Brown's proposal, which involves explicitly recognizing the role of engineering in the National Science Foundation, is relatively controversial, and I think it is fair to say that things don't happen in the Congress unless the national interest is compelling.

I would like to ask—you used such words as further increases in engineering would be desirable and that the reflection of the increased effort this year is certainly entirely warranted. Can you address the question of how compelling the changes suggested by Mr. Brown are?

Dr. **Drew**. Well, Mr. Chairman, it is not clear to me, by the way, why this proposal is, quote, controversial. I think the recognition of the importance of engineering within the Foundation has been taking place. The concern perhaps may be that, like many pendulum swings, it may be swinging too strongly. What I am suggesting to you, and what I suggested in the testimony, is that we don't see that at all as being a threat. Engineering is still the smallest, as I pointed out, by a very large number in dollars, of the research support programs within the Foundation.

There are things which are proposed in the bill—for example, the enlargement of the National Science Board to 36 members—which we in the IEEE do not think are necessarily desirable. I should point out that I was part of the Foundation's staff a number of years ago in connection with the role of the President's science advisor, when that was assigned to the Director of NSF. I was the staff director there for the science advisory function. So I saw the workings of the National Science Board and the NSF from the inside for a while.

My conclusion is that, basically, I think the sense that needs to be communicated both to the Foundation and to the Administration—which, through the OMB and through the budget review processes, apply their sense of priority to arrive at what numbers come out in the proposals that you see—is that the direction in which they are moving needs the kind of reinforcement that we think is provided by this legislation.

It is not clear that that is enough, however. Their current emphasis needs further reinforcement to have this role grow. To be quite frank, the bill makes explicit reference to engineering, but it is only in your other actions, your response to budget proposals, that you will reflect the sense of increased support for engineering.

That does not come through in the bill. I think there is room for both actions (budget support and this legislation), as I see it. And so I would support very strongly—as a matter of fact, our highest priority is the recognition and the need for additional budget support. Secondarily, we would see that support reflected in the changes that were proposed in that legislation.

Mr. BROWN. Could I offer a comment?

Mr. WALGREN. Mr. Brown?

Mr. BROWN. It was mentioned earlier by a witness that there probably are already five members of the board who are either engineers or have an engineering mentality or some description of that sort. It would be no great change, as I perceive it, if we were to specify that we change the title to Science and Engineering Foundation and specify that some number like six, which would be one more than they already have maybe, of that existing board be trained in an engineering discipline or have a background in an engineering discipline; and then do something more substantive in terms of emphasizing the status of the engineers, particularly in terms of increasing the authorization a little bit more in some of the areas that they are already moving toward.

You would see nothing radical in that kind of approach to it, I would presume.

Dr. DREW. No, sir.

Mr. BROWN. And yet I will venture to suggest that it would still be opposed because it is seen as a threat to a certain status situation at the present time.

My feeling is that we are not going to avoid controversy on this. We are probably going to have to face it and solve it in the usual political way, which means taking a vote and seeing if reasonable politicians don't agree that some reasonable change in status is not in order for the welfare of the society as a whole.

Of course, that is going to test the engineers who will have to lobby for their position, versus the scientists who are going to make all of the usual arguments in support of not changing the Foundation at all. Now, who would win in that kind of confrontation? Sweet reason would probably lose, wouldn't it?

Dr. **Drew**. Mr. Brown, we hope that we never get into that sort of confrontation. If you will, we are all part of a larger family, and some of us represent parts of the family that certainly are closer to the industrial needs that we see as really an important part of the challenge that faces us today.

For example, your comment about the Demming prize and his role in Japan. Quality assurance builds upon a product that already has to have been engineered in a very real sense. And so we view science and engineering as, again, part of a coupled system. We see the importance of engineering as creating the basic products, and then connecting to a larger system in which we focus on the full process whereby those products get produced and into the marketplace in a way which is highly competitive.

So we see the importance of social science and we see the importance of understanding this system. We also feel very strongly that there needs to be an adequate recognition of the role of engineering here, and in society as a whole. We think that the engineering piece, up to this point, has really not received that degree of recognition.

Mr. **Walgren**. The question would be whether you can get that recognition short of this kind of change in the organizational structure of what we now know as the National Science Foundation. Although you say you would hope it would not come to that kind of choice, members of the IEEE have been visiting me in Pittsburgh saying that that issue of recognition is so important for their view of the national interest that they are ready to go to the mat to bring that about, and devil take the hindmost.

What concerns me is that I don't know that we will ever get this kind of change unless the issue is joined, and I hear you almost not joining the issue. I hear you saying you hope it doesn't come to that.

Dr. **Drew**. Well, Mr. Chairman, I think that is exactly the way I would approach it. I think you reflected very fairly some of our membership. Some of our membership would feel very strongly that a National Technology Foundation is the only solution. I cannot say that they are wrong in that because what we are seeing now is a response in the National Science Foundation to some cumulative pressure to move more aggressively in engineering.

I think there is the fear that without the change that is being proposed here, as soon as external conditions, or perhaps a comfortable feeling develops—I mean, similar to the comfortable feeling today about energy in society as a whole. There are those of us who look at the energy field and say, "This is no time for leaders in our society to be comfortable about energy." Perhaps society as a whole has that feeling. But certainly those of us who look ahead at all cannot be comfortable.

Well, we can go through a period when engineering may be looked upon with the same degree of comfort. Therefore, without some clear change that one can lean on and point to to support that engineering role, the fear is, by your constituents in Pittsburgh and elsewhere, that we will fall back into old habits, that the sort of support that I pointed out to you that existed as recently as 1980 would again be the rule rather than the exception.

I think it is in that context that people see the importance of taking this action. But again and again, we recognize that it should not be taken at the expense of the sciences but as a complement to that role.

Mr. Walgren. Mr. Brown?

Mr. Brown. I think we are having a political discussion here more than anything else, but it may be necessary to do that.

I think that the National Science Foundation is making some laudable efforts in the direction of both strengthening engineering and not further reducing the support to the social and behavioral sciences. But I don't think they quite understand the rationale for why they are doing it yet. I don't think they have a concept of how this all fits together into a coherent policy in which the Federal Government should be taking some leadership role.

The proposal, for example, to have the Foundation support these Centers for Fundamental Engineering Research is an excellent suggestion. This is what this committee tried to do with the Stevenson-Wydler Act 5 or 6 years ago, and this administration, when it came in, zero-funded it because it did not fit within their framework.

Now, I think that the pressure of events has caused them to recognize that that is not a totally bad direction to, in effect, add support to fundamental engineering research in certain generic areas which can ultimately be of benefit to the American economy—manufacturing engineering, for example, and some other things of that sort.

But I think there are still sort of two minds on this, and it is in an effort to establish a framework within which we can come to one mind that I am pushing some of these things maybe more than would be justified, maybe even more than you think is necessary at any one point.

But I think we are making some progress by keeping in mind what it is that this country needs, not what it is that basic scientists need or engineers need or anybody else needs.

I am almost positive that if I were completely successful today, and engineering all of a sudden surged to the forefront in terms of national priority, that I would be reminding the engineers in a few years that they can overdo things, too; that we need to give proper weight to support for basic science and for the values that this society really has that we are not meeting, and some other things of that sort.

But right now, I think the pressure needs to be in the direction that I think we are trying to move, toward getting this additional support for that linkage function that we are talking about.

Mr. Walgren. Let me ask Dr. Aaron something. I have always wanted to underscore the point that both of you make of how small the numbers are that we are dealing with in both of these areas and how the changes in percentages can be somewhat misleading when you actually figure out the number of dollars that are involved.

At some point here I had tried to make my own example, where we are increasing by large percentages, in electrical and related engineering functions 71 percent, and we are increasing only $8 million, compared to, in materials research, instead of 71 percent, we are increasing only 19 percent, but we are increasing $16 million, literally double the increase in effort.

So the percentages, I think, really don't speak to where the dollars are going. You both made that point very well.

I wanted to ask Dr. Aaron, as I understand it, the Academy of Sciences has undertaken a survey of research needs in the social and economic sciences, and this is something that I understand they have done in advance in other areas, but now they are coming to social sciences. They have not reported yet, but do you expect that the Academy is going to be able to develop a consensus on research needs in that area?

Dr. AARON. I sit on the committee that is supervising the establishment of a new body to undertake precisely what you have just described. The indications were that that would proceed. It appears to be a major effort that will involve all of the social sciences and education.

I think it will be some time before this new study gets under way. I would call attention to a study of which I am sure you are aware that was put out previously by the National Academy of Sciences and the National Research Council, which was entitled "Behavioral and Social Science Research: A National Resource," that describes past research, endorses what has been done, and in effect gives suggestions about directions in which future research should go. I call attention to that on the top of page 5 of my testimony.

I think your emphasis on percentages as opposed to numbers, if I may return to a remark you just made, is very important. If you cut something by 50 percent, it then takes a 100-percent increase to get back where you were. It is a simple matter of arithmetic, but it is worth keeping in mind.

Mr. WALGREN. That is a nice touch.

As I understand what NSF is proposing now for the social sciences, it is largely related to the computer capability of maintaining and working with data bases, and there has been testimony that I recall that that was a basic need of the social sciences in particular.

Do you feel that the initiative in that area is the proper application for an increase in the social sciences research? It strikes me that this is something that other areas of NSF also would like to see done, so that when they are increasing the behavioral and social sciences, they are also doing—it is almost like a "two-fer" in a way—they are also doing what they would like to do in other areas in terms of computing power and capability.

Would there be a better direction to go?

Dr. AARON. This is an area about which we have had some discussion inside our organization. There may be some branches of the social sciences that are constrained by the size of presently existing supercomputers. Most branches of the social sciences are not so constrained.

As far as the major priority areas for the social sciences, the expansion of supercomputers would be, I think, relatively low on the priority list for most of us. Now, there may be some applications in the area of linguistics and some large simulation models that will strain capabilities. But we are not talking about analytical problems.

The problems in social sciences, by and large, are ones of data and modeling rather than limits imposed by computational—by hardware. So, as I am aware of the enormous costs that can be incurred in these areas, although some of our sciences would benefit from these, I think this would not be an area that we would attach high priority to.

Mr. **Walgren**. Am I misthinking about NSF's proposal as to what they are going to do as a major increase in social sciences? Wasn't it largely in the area of——

Dr. **Aaron**. Much of it is for data, and in that area we do support the development of large-scale data sets. But as I mentioned in my testimony, we would like to have people funded to carry out research on those data sets when the data come in.

Mr. **Walgren**. And is there much strength in this proposal in that area?

Dr. **Aaron**. Less, because we think there is need in that area, and we would urge a return to the level of funding in 1980. A larger percentage increase this year than has been proposed deserves the most serious consideration.

The degree to which research activities have been curtailed—one might almost say devastated—in many of the social and behavioral sciences over the past few years is hard to exaggerate.

Mr. **Walgren**. Can you elaborate on that? What has been the change in the existing capacity out there, the capability?

Dr. **Aaron**. Let me call attention to the second table that I included in my testimony that breaks down funding levels in some detail among behavioral and neurosciences and social and economic sciences.

It is apparent that in many areas, in nominal dollars, funding levels drop by half; adjusted for inflation, by even more.

Given prior-year commitments, that means it was simply impossible to undertake new starts, so that no new research in many areas was funded for extended periods of time.

A drop of spending by half does not translate into a drop of new research activities by half but by a much larger percentage, and it is that kind of effect, or those kinds of cuts, that have had very serious effects on the research activities that NSF has been able to undertake. Now, that is turning around, and we understand the role that you and others have played in that. But we have a long way to go.

I would be glad to supply for the record additional material in support of the specifics. I do not have at this time details, discipline by discipline, area by area. But I would be glad to try to supply those for you.

Mr. **Walgren**. I think that would be helpful.

[The information follows:]

The following paragraphs on the impact of the severe cuts in the budgets for social and behavioral science research at the National Science Foundation (NSF) during FY 1981 and FY 1982 were prepared at the request of the Subcommittee on Science, Research and Technology of the House Committee on Science and Technology.

There are two ways of looking at the impact of these reductions. First, there are impacts that can be measured. This would include such factors as the number of submissions or proposals to the social and behavioral science programs at NSF, the average amount of an award in constant dollars, the budget for a research program in constant dollars, the amount given for research proposals compared to the amount requested, and the actions taken on submissions to the social and behavioral science programs. We will show that on almost all these measures and in almost all the social and behavioral science research programs at NSF, the budget cuts had a negative impact.

The effects of the budget cuts are clearly demonstrated by statistics on the social and behavioral science research programs at NSF. For example, in the Division of Social and Economic Sciences (SES), the budget declines from FY 1980 to FY 1982 are sizeable. As shown in Table 1, the proportion of research dollars awarded to dollars requested for successful proposals declined by over 15% from FY 1980 to FY 1982, from 73.4% to 58%. The average annual award went down in constant dollars from over $21,000 to less than $14,000 in the FY 1980 to

FY 1982 period, and declined by 50% from the FY 1978 levels (see Table 3). The budgets for the programs in constant dollars were reduced from $15.5 million to $8.55 million, a reduction of over 44% in 2 years (see Table 4). The number of competitive proposals received went from 1381 in FY 1980 to 1183 in FY 1982 and continued this downward trend to 1089 in FY 1983 -- almost 300 fewer proposals in the 3-year period (see Table 5).

In specific program areas these impacts are even more pronounced. The average amount awarded in Economics went from $26,203 in FY 1980 to $14,242 in FY 1982; in Sociology from $21,236 to $13,313. In other programs the reductions were somewhat smaller, but it is clear that the amount of money being awarded to investigators declined substantially.

In Economics the percentage of the amount awarded compared to the amount requested in the FY 1980 to FY 1982 period declined from 72.8% to 58%, in the Law and Social Science Program from 81.6% to 58.3%, in the Measurement Methods and Data Resources Program from 93.6% to 31.4%. These declines are indicative of the scarce funds that were available for these programs.

If we look at program budgets in constant 1972 dollars in the years 1980 to 1982 Table 4), the Geography budget was reduced by almost 60%, the Economics, Sociology, Political Science, and Measurement Methods and Data Resources Programs were reduced by over 50%, and the History and Philosophy of Science Program budget by almost 50%.

With less money to go around and reduced awards to investigators, social scientists, even if they survived the application process, became discouraged and stopped submitting as many proposals. Did this mean that social scientists were no longer interested in research? Not at all. They simply got the message of the administration and stopped applying. The number of competitive proposals in Political Science shrank from 167 in 1980 to 98 in 1982, in Sociology from 254 to 134 proposals, in Geography from 115 to 81, and in Law and Social Science from 152 to 94.

The evidence for the social and behavioral science programs in the Division of Behavioral and Neural Science -- Social and Developmental Psychology, Memory and Cognitive Processes, Psychobiology, Anthropology and Linguistics -- indicates similar effects of the devastating reductions in funds. The budgets in constant 1972 dollars were reduced between FY 1980 and FY 1982 by over 60% in Social and Developmental Psychology, by 33% in Linguistics, by almost 30% in Psychobiology, by 24% in Memory and Cognitive Processes, and by 22% in Anthropology. The average amount given for an award was reduced by over 20% in Linguistics and Anthropology. The number of proposals submitted decreased from 217 to 94 in Social and Developmental Psychology, from 637 to 418 in Anthropology, from 159 to 72 in Linguistics, and from 134 to 88 in Memory and Cognitive Processes.

A second way of looking at the impact of the budget cuts is to examine their immeasurable effects. These effects cannot be quantitatively demonstrated but they are nonetheless very real. For example, how many research projects never got off the ground? How many significant long-term investigations were never even proposed because of the reductions in funding or the uncertainties in funding? How many graduate students were discouraged from continuing their studies? How many from even beginning to do graduate work in the social and behavioral sciences? How many of these students were not able to receive the important research training that comes from participation in graduate faculty research projects?

One social scientist, Dr. Thomas Juster of the Institute for Social Research at the University of Michigan, reviewed the NSF programs in the social and behavioral sciences last year and discussed the long term effects of the cutbacks proposed by the administration in FY 1981 and FY 1982. He notes that the cutbacks sent a signal, an unambiguous message, to every serious social scientist suggesting that they should not waste their time in trying to plan an ambitious if costly research agenda because it has little prospect of being approved. Furthermore, intellectually ambitious research proposals -- those designed to add to the body of knowledge in the social and behavioral sciences -- have little prospect of getting support because of the budget cuts. Even if support were forthcoming, it would likely be at much lower levels than those proposed.

The sharp cutback in funding for basic social and behavioral science research meant that students being trained in graduate schools were less involved in research because there was less research support available. Potential graduate students in the social and behavioral sciences looked elsewhere for training. Corporations and universities that hire people trained in the social sciences will eventually have fewer and fewer people to choose from. This can create a cycle in which future research and development is hindered by a diminishing number of well-trained social scientists. Projects such as the National Election Study and the General Social Survey, scientific indexing and preparation of major reference works in the history and philosophy of science, and university based laboratory radiocarbon or potassium argon dating techniques so important to physical anthropologists, all crucial to training graduate students, were among those social and behavioral science projects curtailed because of the budget cutbacks. In addition, reductions in funding eliminated or sharply curtailed participation in summer institutes crucial to the intellectual nurturing of junior social scientists interacting with senior members of the profession.

Quantitative analytical research requires research assistance, significant amounts of computing resources, and many hours of professional time spent devising appropriate tests of whatever social science proposition is being tested. The cuts sharply curtailed high quality empirical investigations of this type, and in many of these, longitudinal measurements essential to the study could not be continued. These included linguistics research on the language acquisition process, geographic research on regional economic and population changes, longitudinal analyses of particular disputes, anthropological research efforts to acquire a "long core" from a deep African lake to study fossils, and much social and developmental psychological research.

Finally, it appears the cuts had a significant impact in stifling creativity. Since much of the excitement in scientific work revolves around the development of major new initiatives, constrained resources militate against those opportunities. Among those programs affected by the reduction were a significant effort to identify the determinants of various types of measurement errors in surveys, a promising program of experimental laboratory research in economics that was used successfully to test elements of theory in decision-making under uncertainty, a new program on the use of experimental methods to study democratic decision-making processes, anthropological research on human origins, computer simulations of cognitive processes, the impact of environmental stress factors on human behavior, and experimental research on the issues involved in the presentation of scientifically complex information in adversarial proceedings. All of these research projects were curtailed or eliminated as a result of the budget reductions.

In summary, in both measurable and important immeasurable ways, the budget cuts of FY 1981 and FY 1982 significantly and adversely affected the social and behavioral sciences.

NATIONAL SCIENCE FOUNDATION

% of Dollars Awarded to Dollars Requested for Successful Research Proposals
Table 1

	1978	1979	1980	1981	1982	1983
Division of Social and Economic Sciences	61.3	73.3	73.4	59.0	58.0	60.6
Economics	83.2	80.4	72.8	54.1	58.0	61.1
Geography	69.3	72.7	65.5	62.2	63.0	54.2
Measurement Methods and Data Resources	19.3	52.2	93.6	56.1	31.4	50.8
Political Science	73.5	68.4	75.2	70.7	84.3	61.5
Law & Social Science	72.1	91.1	81.6	61.1	58.3	51.5
Sociology	69.8	68.5	68.0	68.6	68.2	67.9
History & Phil. of Science	66.9	68.3	68.6	39.7	59.9	75.2
Division of Behavioral and Neural Sciences (selected programs)						
Psychobiology	71.3	62.4	69.7	66 3	64.8	56.0
Memory & Cognitive Processes	66.8	68.1	74.2	77.3	76.5	84.6
Social & Developmental Psych.	63.3	66.8	65.7	64.3	67.6	75.1
Linguistics	67.3	62.8	55.5	61.6	71.6	65.6
Anthropology	69.1	74.1	80.0	73.2	66.0	59.5

Table 2
Success Rate of Competitive Proposals (in %)

	1978	1879	1980	1981	1982	1983
Division of Social and Economic Sciences	38.4	40.7	36.7	30.7	34.7	35.5
Economics	52.5	53.7	47.6	37.7	37.8	43.0
Geography	34.8	34.8	31.7	30.8	39.1	35.4
Measurement Methods and Data Resources	36.8	38.6	27.7	26.7	38.6	50.9
Political Science	36.4	39.8	33.8	39.1	42.6	36.7
Law & Social Science	46.3	29.0	20.3	18.1	29.7	24.0
Sociology	23.6	28.5	28.2	22.5	30.7	33.3
History & Phil. of Science	43.7	42.3	39.5	36.4	40.6	45.6
Division of Behavioral and Neural Sciences (selected programs)						
Psychobiology	29.6	29.4	32.2	29.7	32.1	27.6
Memory & Cognitive Processes	24.1	23.0	32.6	21.6	32.9	25.9
Social & Developmental Psych.	23.6	23.0	22.5	19.9	28.3	21.7
Linguistics	34.6	27.9	38.1	28.8	47.8	40.7
Anthropology	30.4	31.9	32.4	31.9	36.0	34.1

Table 3
Average Annual Award (in constant thousand $)

	1978	1979	1980	1981	1982	1983
Division of Social and Economic Sciences	26.4	20.6	21.5	17.0	13.9	13.0
Economics	30.3	26.3	26.2	18.5	14.2	12.8
Geography	28.7	14.7	16.5	13.3	10.2	9.3
Measurement Methods and Data Resources	132.5	32.7	59.4	40.1	35.3	27.6
Political Science	24.2	16.7	18.1	15.9	19.0	13.3
Law and Social Science	16.0	16.3	19.4	15.5	13.6	13.1
Sociology	24.0	22.1	21.2	18.7	13.3	15.3
History & Phil. of Science	10.7	12.5	9.6	7.0	5.2	5.4
Division of Behavioral & Neural Sciences (selected programs)						
Psychobiology	22.4	17.3	15.4	16.4	15.5	15.4
Memory & Cognitive Processes	23.7	21.1	22.7	17.4	19.7	18.6
Social & Developmental Psych.	23.5	19.2	21.6	16.6	21.8	21.4
Linguistics	17.1	14.7	16.4	15.4	13.0	12.5
Anthropology	12.0	12.1	15.2	13.5	11.9	10.3

Table 4
Budget (in constant 1972 hundred thousand $)

	1978	1979	1980	1981	1982	1983
Division of Social and Economic Sciences	166.9	157.8	155.0	129.1	85.5	95.2
Economics	60.9	58.6	60.8	38.5	30.2	32.8
Geography	11.7	9.0	8.4	5.6	3.4	3.7
Measurement Methods and Data Resources	13.8	27.3	28.1	19.9	13.7	15.2
Political Science	19.4	21.4	20.4	15.0	10.0	10.9
Law and Social Science	6.0	5.5	5.1	6.0	5.3	5.7
Sociology	26.7	21.9	21.7	15.3	10.6	11.2
History & Phil. of Science	10.2	9.6	8.4	5.6	4.3	5.0
Division of Behavioral & Neural Sciences (selected programs)						
Psychobiology	25.0	24.6	24.5	22.0	17.2	17.4
Memory & Cognitive Processes	13.6	15.0	14.5	12.3	11.0	10.4
Social & Developmental Psych.	20.1	20.2	18.2	13.2	7.2	10.4
Linguistics	13.1	14.7	14.9	11.4	10.0	9.4
Anthropology	35.9	37.1	36.2	30.6	28.4	27.2

Table 5
Competitive Proposals Received

	1978	1979	1980	1981	1982	1983
Division of Social and Economic Science	1275	1160	1381	1293	1183	1089
Economics	348	320	373	301	347	257
Geography	130	135	115	111	81	85
Measurement Methods and Data Resources	36	47	77	76	44	44
Political Science	130	156	167	116	98	163
Law and Social Science	95	65	152	137	94	112
Sociology	251	218	254	174	134	124
History & Phil. of Science	209	197	201	133	185	139
Division of Behavioral and Neural Sciences (selected programs)						
Psychobiology	273	266	247	230	193	202
Memory & Cognitive Processes	162	169	134	108	88	125
Social & Developmental Psych.	224	239	217	103	94	116
Linguistics	204	219	159	121	72	109
Anthropology	708	614	637	507	418	532

Table 6
Total Actions (includes competitive and non-competitive awards, declinations, and withdrawals)

	1978	1979	1980	1981	1982	1983
Division of Social and Economic Science	1059	1099	1110	1379	1111	1291
Economics	271	287	316	299	324	344
Geography	106	113	119	110	70	100
Measurement Methods & Data Resources	27	59	58	74	52	67
Political Science	122	134	161	144	105	150
Law & Social Science	62	75	80	123	99	116
Sociology	227	218	207	206	159	147
History & Phil. of Science	147	171	158	160	161	160
Division of Behavioral and Neural Sciences (selected programs)						
Psychobiology	280	241	262	225	212	233
Memory & Cognitive Processes	151	173	131	127	105	132
Social & Developmental Psych.	180	229	197	162	73	129
Linguistics	181	188	142	139	90	114
Anthropology	606	574	571	451	442	502

Mr. **Walgren**. I gather that the most severe impact would be in personnel that are involved or not involved. If you lose all your research assistants because there is not anything going on, and they are out either going to other disciplines or just having abandoned the field, that is a very significant and important thing that we try to factually gauge.

If it is possible to look at the area in view of the cuts that we have implemented for several years and see the damage, I think it would be an interesting case study that we should view accurately. So if there is some direct numerical or limited or finite view of that, we ought to try to have it.

Dr. **Aaron**. We will try to bell the cat.

Mr. **Walgren**. All right.

If there is nothing further, let me thank you both on behalf of the committee for being available to us. We look forward to seeing more of you, and we appreciate very much your contribution.

Mr. **Aaron**. Thank you.

Mr. **Drew**. Thank you, Mr. Chairman.

Mr. **Walgren**. We will reconvene at 9 o'clock, then, tomorrow morning.

The hearing is adjourned.

[Whereupon, at 4:15 p.m., the committee recessed, to reconvene at 9 a.m., the following day, Wednesday, Feb. 29, 1984.]

1985 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

WEDNESDAY, FEBRUARY 29, 1984

House of Representatives,
Committee on Science and Technology,
Subcommittee on Science, Research and Technology,
Washington, D.C.

The subcommittee met, pursuant to recess, at 9:05 a.m., in room 2325, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Brown, Boehlert, Skeen, Dymally, and Durbin.

Mr. Walgren. Let me start us off.

Today is the final hearing on the National Science Foundation's authorization process for this committee. As yesterday, we will today, through a number of distinguished witnesses, give the subcommittee an opportunity to hear the views of people who are close to this area and involved in it on an array of cross disciplinary issues and budget priorities.

The witnesses today include: Joe Wyatt, the chancellor of Vanderbilt University; Robert Kersten, the dean of the College of Engineering, University of Central Florida; and Dr. Robert Barker, vice president, Research and Advanced Studies, Cornell University.

We welcome you. It is very helpful to bring us into direct contact with you and build a record from which we can properly base directions in which we hope to press the National Science Foundation to go. So we really do appreciate the perspectives that you bring to this and appreciate your time and effort.

Your written statements will be made part of the record automatically, so please feel free in our discussion period here to focus on the things that you feel are particularly important, and communicate them for this part of the record in whichever way you feel is most effective. We are very pleased you are here.

We will start with Mr. Wyatt. Welcome to the committee.

[A biographical sketch of Mr. Wyatt follows:]

JOE B. WYATT

Joe B. Wyatt was Vice President for Administration at Harvard University from 1976 until 1982. He went to Harvard in 1972 as Director of the Office for Information Technology. Since 1972 he has been a Senior Lecturer in Computer Science in the faculty of Arts and Science (Division of Applied Science) and in the John F. Kennedy School of Government. In 1980 he was made a standing member of the faculty of the Institute for Educational Management.

Prior to going to Harvard, Wyatt had been Associate Professor of Computer Science and Director of the University Computing Center at the University of Houston from 1965 to 1972. He began his professional career in the digital computer laboratory at General Dynamics Corporation in Fort Worth, after having earned the Bachelor of Arts in Mathematics at the University of Texas in 1956. While with General Dynamics, he earned the Master of Arts degree in Mathematics in 1960 from Texas Christian University where he was an Instructor in Mathematics until 1965.

From 1973 to 1981 he was associated with EDUCOM, a Princeton, New Jersey based consortium of 450 universities that has developed computer programs and computer networks for sharing information and resources. After a year as President and Chief Executive Officer of EDUCOM, Wyatt became Chairman of the Board of Trustees in 1976, a position he held until 1981. Major projects at EDUCOM during his tenure included the development of a national computer network called EDUNET and the development of a computer-based financial planning system called EFPM that is currently used by over 150 colleges and universities in the United States, Canada and Europe.

Wyatt holds a number of government and civic appointments. From 1967 to 1972 he was a member of the Long Range Planning Committee of the Houston Chamber of Commerce, a role which he continued with the Boston Chamber of Commerce after his move to Harvard. In 1976, Governor Michael Dukakis appointed Wyatt to the Board of the Massachusetts Technology Development Corporation, a venture capital financing group for technology-based companies in Massachusetts. Since 1976, he has served as Vice-Chairman of the Board and Chairman of the Investment Advisory Committee, and in 1981, Wyatt was reappointed by Governor Edward J. King. Since 1978 he has been Chairman of the Advisory Committee for the Division of Information Science and Technology Research of the National Science Foundation, and since 1980 Chairman of the Advisory Committee on Technology in Education in the Office of Technology Assessment. He is a member of the Policy Board of the National Association of Independent Colleges and Universities, a member of the Corporation of the Boston Museum of Science, and a member of the Board of Trustees of the Harvard University Press.

Wyatt has published in the fields of computer science and management. He is editor-in-chief of the new Journal for Applied

Management Systems, published by Crane, Russak in New York. He has been a contributing author to books on management information systems and computer system design. He has written articles on computer networking, computer system simulation and management for several referred journals in the United States, Europe, and Australia. He has recently completed studies on the management systems in the Congress of the United States and on the role of technology in decision-making at the Federal Aviation Agency sponsored by the Rand Institute. Among his specialties is the use of advanced technology in libraries, a subject on which he has written for the Journal of American Research Libraries (1979). He has co-authored a book on Financial Planning Models for Colleges and Universities (1979) and is currently writing a book on management systems under contract to a New York publisher.

Wyatt has been principal investigator for a number of research projects most recently including "Research in Computer Network Utilization Methodologies" for the National Science Foundation and "Adaptive Financial Planning Models for Colleges and Universities" for the Lilly Foundation. In 1975, Wyatt was granted his first United States Patent in the area of computer-aided design and manufacturing.

Wyatt is a member of several professional societies including the American Association for the Advancement of Science, the Institute for Electrical and Electronic Engineers, and Sigma Xi. He is a Corporator of the historic Orchard House in Concord, Massachusetts and a member of the Concord Antiquarian Society. Wyatt is also a member of the Aircraft Owners and Pilots Association and holds a commercial pilot certificate.

Born in 1935 near Tyler, Texas, Wyatt married Faye Hocutt in 1956. They have two children, Joseph Robert, 21, who is a rising junior at Vanderbilt, and Sandra Faye, 19, a freshman at Southern Methodist University.

STATEMENT OF JOE B. WYATT, CHANCELLOR, VANDERBILT UNIVERSITY

Mr. WYATT. Thank you, Mr. Chairman.

It is a pleasure to be with you this morning at this early hour, and I am delighted to be able to comment on the National Science Foundation's fiscal year 1985 authorization.

You asked me three questions, which I won't repeat in the interest of time, but they have to do with organizational questions and budget questions relating to supercomputers; a research program dealing with Information Science and Technology; and the priorities on these matters. I would like to distinguish between three segments of work in this general area.

First is the use of computers as an instrument for research; that is, as a resource for research calculations and information processing. The second is computers as a subject of research, research in the design and architecture of computers; and, finally, the information sciences as a subject of research. That would include, for example, algorithms relating to the way biological organisms process information, the coding of information, and a host of issues relating generally to how information is processed and stored by living organisms as well as computers.

There are three reports. One report has been put in the record in prior testimony, the Bardon-Curtis report—and I won't ask that it be added here, but I will refer to it. The second is a report from a task force that I chaired a number of years ago that led to the establishment of the Division of Information Science and Technology in the National Science Foundation, a new research directorate that has prospered, in some measure at least. And, finally, a report titled "The Report of the Information Technology Workshop" edited by Robert F. Cotellessa and sponsored by the Directorate for Engineering of the National Science Foundation in collaboration with the Department of Defense, published October 1, 1983.

There are a number of research problems in the sciences that now require advanced computer resources. For purposes of this discussion, I will refer to the most advanced computer resources as supercomputers—those computers that embody the fastest and largest in terms of capability and capacity; In the May 23 meeting that led to the Bardon-Curtis report, the 13 scientists that were there—I was included in that group—listed examples of science research areas, including the social sciences, that simply will not move forward without access to supercomputer resources. And it is also true that those supercomputer resources are simply not forthcoming at the level now required for this work.

A second point, and one that I would not want to be missed, is that it is not just the resource availability for the calculations in the physical and social sciences. New research methodologies are derived by working on computer systems of this sort; that is, by having access to these systems the scientists and the people designing the systems learn and develop new methodologies, new structures, new architectures for computer systems.

We've had a number of examples of that in the past. Probably one of the better known is the set of algorithms that John Tukey evolved for what are referred to as fast Fourier transforms, a particular methodology dealing with Fourier transforms (mathematical transformations that allow for the investigation on a very efficient basis of many kinds of physical problems). These discoveries were derived from an active association with computer resources, and therefore it is important for those people who use supercomputers to work closely with those who design and research the design of these resources; and the computational methodologies and informational representations that are used there, that they work closely with one another.

So it is important that we have here the concept of an open interdisciplinary resource, supercomputer resource, inhabited by clusters of researchers and support staff, and in addition with local area networks having graphics and other state of the art input/output capability, having links to national networks for file transfer and communication to people when they are not located at the resource and for technical development teams for the refinement and enhancement of the supercomputers and the associated architectural resources that are required for supercomputer use.

The concept of projects for research and computational methodologies and information science related to supercomputers is also a very important issue. It seems clear that we will need to experience some breakthroughs in the processing of information in order to achieve the results that are projected by the science researchers. That is, it is not just a matter of brute strength in the application of supercomputer resources.

It is also a matter of new software methodologies and new hardware structures with accompanying software methodologies. There is clearly a question of philosophy involved here, how one gets from where we are now to the provision of adequate computational and information processing resources.

A philosophy that I think is very important is to build on existing university centers where possible. That is, we have some centers of activity in this country that are already using either supercomputers or very advanced computer systems, and I think it is important rather than reinventing all of these resources that we augment those centers where it is possible to do so. And I should add that Vanderbilt is not one of those places where a supercomputer exists, so I am not grinding an axe here for my own university.

I think it is an important philosophy, however, for prudent planning and also to recognize the fact that one does not simply aggregate overnight the collection of people and resources that make up such a resource. It takes many years, in fact, to develop the cadre of people and the culture that goes along with it.

I also think it is important to consider augmenting national centers outside the university area; that is, the Government laboratories. Los Alamos and Livermore provide the most advanced computer services for Government laboratories now. There is not a single university center that compares with those facilities. So they are a model in many respects for the university centers that I am suggesting. And, in addition, it seems to me that those resources perhaps could be augmented to provide services to science researchers.

Third, I think it is important that we consider developing a few new centers; that is, to allocate enough money to solicit proposals for novel and imaginative proposals to begin new centers for supercomputer resources. My own guess is that if that is done, we will receive some very imaginative proposals and very likely would be able to provide some kinds of services that simply are not now available.

The other two points are equally important, presuming the first three, and that is that we provide funding for the interconnection and augmentation of the national networks. There will be occasions when scientists will wish to come to these resources and work in the culture for a while. But, by and large, a great amount of the work will best be done by people working at their own home base, their own university, and communicating with the supercomputer resource by means of one of the national networks, and what is referred to in the vernacular as front-end systems that allow the connection from local area networks to the national network.

Now, this will require, I believe, a very bold step, a set of bold steps, and the necessary condition for taking those bold steps is an adequate level of funding. I simply do not believe that we can do the five things that I have described adequately without a level of approximately $100 million. I could break it down for you in some respect, if that would be helpful. But I can tell you that I am involved with an ad hoc committee right now over at the Foundation that is engaged in precisely that activity, and it is our intention in this group to be able to submit to you breakdowns and support those breakdowns later in this session.

Mr. WALGREN. When do you think that might be available?

Mr. WYATT. We have our next meeting next Monday and Tuesday, and we hope to refine those estimates on those 2 days. I hope that they would be available shortly after that time. In other words, next week is our intention.

Mr. WALGREN. We would be most interested and anxious to have that judgment, and in a way that we could make it part of the record and work with it with the other members of the committee. So please know that we will be waiting for that.

Mr. WYATT. Good. We hope we can find a way to get it over to you soon.

Let me speak, finally, to one other matter; that is, the organizational question that you have asked, the matters of organization of the Foundation. I, as I said in my written testimony, chaired a task force some 5 or 6 years ago, appointed by then-Director Richard Atkinson. We submitted a report that called for the establishment of a new research division, a Division of Information Science and Technology. That division was begun. It was headed by Howard Resnikoff, a professor from the University of California, who joined the Foundation after a national search. He was assisted by Dr. Edward Weiss, the Associate Director of that division.

I might say that everyone, including me, was more than delighted by the kind of response that we got from the science communities. We had, almost immediately, a large flow of outstanding proposals. Within the framework of the small amount of money that was allocated, we were able to fund only the very best of a collection of outstanding proposals. It was our hope that this division would flourish located in the Division of Biological and Behavioral Sciences. It was, and is, my feeling that this intellectual climate would be a good climate to begin to stimulate thinking about the association of technology and information science and those areas where biology and behavioral sciences intersect, as well as with fields like economics.

I still believe that is on solid ground. But I also believe that there may be some organizational problems where somehow the organism is not able to flourish with the organizational structure.

Two years ago, Dr. Resnikoff left for a position at Harvard University. Dr. Weiss resigned a short time ago. One of the sponsors of the report that I cited, Dr. Sanderson, Assistant Director of the Foundation for Engineering, has gone to the private sector. I am not saying these are totally frustrated individuals who have left the Foundation because they are angry; that is not it. But I do believe there are some questions there that could stand some examination by a group—and I am going to propose a group to the National Science Board that would have as its nucleus Science Board members to examine the Foundation relative to all the areas that perform research in the areas related to computer science, information science and engineering.

In addition, I think it is also important that that group consider the optimum organizational structure for the management of the supercomputer resources. That is an area that NSF does not have a good deal of experience with; that is, the management of large-scale resources. There are particularly large-scale computer resources and networks, and I think that alone probably would legitimize a review by a high level task force of this type.

Now, the ad hoc committee will be making some recommendations on the initial organizational structure, but it is my belief that this organizational structure has national implications and should be considered no matter what we recommend by a high level group of that sort.

To end this part of my testimony, let me say again that these are very important areas. They are areas where we find ourselves falling behind in some respects. Two of the 13 scientists at the meeting that I attended on May 23 last year are doing a good part of their computational work in either Japan or West Germany because they can find supercomputer resources there not available to them in this country. I don't think we want to allow that kind of thing to exist.

Thank you.

[The prepared statement of Mr. Wyatt follows:]

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUB-COMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
FEBRUARY 29, 1984
JOE. B. WYATT
CHANCELLOR
VANDERBILT UNIVERSITY

Chairman Walgren, distinguished members of the Sub-Committee on Science, Research and Technology, Ladies and Gentlemen, I thank you for the invitation to speak briefly to you here today in conjunction with the National Science Foundation's Fiscal Year 1985 Authorization.

You have asked specifically for my views on three questions: 1) the ability of the present NSF organizational structure to address issues which cut across various NSF directorates, such as super-computers; 2) the coordination of programs among directorates which have responsibility for Information Science and Technology; 3) the priority NSF allocates to various aspects of Information Science and Technology research.

Last September 28, I testified before the Sub-Committee on Investigation and Oversight concerning the use of Information Technology in Education. In that testimony, I called for four action items. The first action item suggested that Congress should support a major effort in the development testing and distribution of interactive educational software that uses the latest developments in computer video, audio and communications technology to provide augmented support for imaginative and innovative teaching. The second action item suggested that large scale super-computer resources be made available to university researchers on a much larger scale. I suggested a funding level of $200 million per year for the foreseeable future in order to provide for fully configured and fully supported regional super-computer resources conveniently located geographically to the major research universities of America and linked continuously by electronic communication networks to hundreds of smaller computer systems located in university research laboratories. Third, I suggested that Congress should use its powers to eliminate unintended regulatory barriers and to encourage improvements and incentives for the development of intellectual property in those numerous areas where education and information technology are likely to yield fruit unless impeded or discouraged. Finally, I suggested that Congress should encourage and support, at increased levels, basic research in computer and information sciences.

I am pleased to be able to report that the first recommendation has led to action. House Resolution 4628, introduced two weeks ago by Congressman Albert Gore, Jr. proposes the establishment of the National Educational Software

Corporation. I support, indeed helped draft, House Resolution 4628. I will speak to it in other forums, and I ask that you support it.

I have also seen action on the third action item by the Congress. Two weeks ago I participated in a symposium conducted by the Library of Congress for the Judiciary Committee of the House of Representatives and the Judiciary Committee of the Senate of the United States Congress on the matter of the Copyright Act and other legislative regulatory issues concerning the development and use of computer-based information and computer software. It was most encouraging for all of us who organized the symposium that Congressman Kastenmeier and Senator Mathias were present along with members of their Committees through the weekend for discussions with us on these important issues.

So I come to you today most encouraged by the responsiveness of the Congress of the United States and its members to these important issues. And I wish to speak to the other issues addressed in your three questions.

COMPUTER RESOURCES FOR RESEARCH

On May 23, 1983, NSF held a workshop with thirteen scientists from diverse disciplines to help define and discuss the needs for large scale computing and networking resources for academic research in the United States. I was one of the thirteen. We were joined by Drs. Marcel Bardon and Kent K. Curtis from the National Science Foundation, along with members of their staffs. Researchers from the physical sciences, the social sciences and engineering were represented in the panel. A report resulted entitled "National Computing Environment for Academic Research," published by the National Science Foundation in July 1983, known generally as the Bardon-Curtis Report. Building on the background of the numerous excellent studies which preceded it, the Bardon-Curtis Report is one of the most lucid and persuasive arguments yet put forth for improving the computer resources that are essential for science research. I ask that it be made a part of this record.

I would like to summarize three of our principal conclusions.

1. There is an immediate need to make super-computers more available to academic scientists and engineers. Science has passed a watershed in using computers for research. Very large scale computers, called super-computers, have become the means for making new discoveries in all important fields of science. Several problems cannot now be solved because of the limitations in capability of current computer systems.

These include the simulation of bi-layer membranes in biology, the modeling, of larger, more interesting molecules using the basic equations of quantum mechanics and chemistry, large scale engineering models for non-numeric processing essential to robotics and knowledge based systems, and the capacity for modeling, even in a limited way, human intellectual processes in information science. These are but a few of the areas requiring the computing capability of the most advance super-computers today and in the future. The actual magnitude of the requirement is difficult to assess because lack of opportunity has artificially depressed the current level of activity in university research laboratories. Our estimate of the near term need is for ten super-computer systems, including at least one advanced Vector computer.

2. A large gap exists between current need and available support for mini computers, attached processors, work stations, high precision graphics, local area networks and other local facilities required as part of the working environment for the use of super-computers in the hierarchical arrangement required for their effective and efficient use.

3. National computer networks are necessary to link

scientists wherever they are to super-computer resources and to the local area networks of each other. The design of the national network must receive special attention. Heterogeneous computer networks are already growing in the United States in many different directions. The Defense Advanced Research Project Agency, implemented ARPANET beginning in the late 1960s. In the late 1970s, EDUCOM, a non-profit consortium of over 400 colleges and universities, announced the operation of EDUNET, a computer network founded to meet the general networking needs of higher education. The National Science Foundation is supporting the development of CSNET, a network for the computer science research community. In May 1981, BITNET was initiated, in the northeastern part of the United States and now consists of about 60 computers located at approximately 20 universities. BITNET is based on a software product developed and used internally by IBM Corporation to support a multi-national internal corporate network called VNET, of approximately 1,000 nodes. USENET is an informal network of over 400 computer systems, using the UNIX (trademark of Bell Laboratories) operations system. There are several important library networks connecting libraries in higher education and elsewhere that include the Ohio College Library Consortium, the Washington Library Network and the Research Libraries Information Network, among others. Each of these networks is enormously useful to its constituents; however, each is incompatible with the other. Moreover, the capabilities of some of the networks are insufficient for the types of use required by academic research scientists using super-computers. However, the technology exists to perform some interconnections of these networks to build on the existing base of capability and to add where necessary increased band width and protocols. It is this planning and implementation that must be a part of the initial effort in establishing the National Computing Environment for Academic Research.

We propose a special supplement to the budget of the National Science Foundation for these purposes. It is divided into four areas: local facilities, super-computers, networks and computational and information sciences. The total funding requested for fiscal year 1985 is $188 million. The current budget proposal before you suggests a level of $20 million. I ask that you consider an increase of that amount to the recommended level.

Our estimates are conservative, and they are realistic for a near-term national effort in academic science and engineering. But even the suggested investment would not provide computing facilities for academic researchers in universities comparable to those at a typical national or industrial research laboratory. And our university scientists are already engaged in traveling to foreign countries, notably West Germany and Japan, to perform large scale computations that they are unable to perform in the United States because of lack of access to facilities or lack of funds to purchase super-computer services. It is but a beginning, a conservative beginning, but history tells us that investments in basic research lead to the development of new science and new technology worth many thousands of times the original investment. Now is the time to invest in computer resources for academic research.

There are several important guidelines which must be followed. 1) Access to these resources and the guidelines for development of these resources must be governed by the peer review process. 2) The development of new and augmented computer resources should be based on successful models in government and industrial laboratories. These models are applicable for super-computer resources, local area networks, user work stations and front end processors and the support services that are required to advise and assist effective use.

3) The overall management and governance of the national computing environment for academic research should be derived from a consortium of scientist users, university executives, representatives from government and industrial laboratories and the NSF.

With the small amount of funding now available to NSF, a modest investment in planning has already begun. The National Science Foundation has appointed an ad hoc panel for the planning and implementation of an initial national computing environment for academic research. The ad hoc panel has met once and plans to meet again on March 4 and 5. Dr. Knapp is directly involved with the deliberations of the panel, as are Drs. Barton and Curtis. Dr. Edward Hayes is coordinating the NSF staff work for the panel. Our ultimate success will depend on the funding levels for the national computing environment for academic research and the organization which can be derived to manage and operate the national computing environment. As a part of the funding, it is my recommendation that the Congress request that, for next year's budget submittal a complete plan for the governance and overall management of the National Computing Environment for Academic Research be produced by the National Science Foundation in consultation with the science and engineering community.

INFORMATION SCIENCE AND TECHNOLOGY

In August of 1977, a special task force which I chaired, submitted its report to then Director of the National Science Foundation, Richard Atkinson. I chaired that task force, and I ask that its report be made a part of this record. Seven major recommendations were contained in the report. The first was that the National Science Foundation establish a new research program in Information Science and Technology. In its recommendation, the panel suggested that this new research program be closely related to computer science, computer engineering and the physical and behavioral sciences. Ultimately, it was determined that the most appropriate organizational location for the Division of Information Science and Technology was in the directorate of Biological and Behavioral Sciences. The first director of the Division was Dr. Howard Resnikoff, a University of California Professor, appointed after an extensive national search. Dr. Resnikoff was assisted by Associate Director, Dr. Edward C. Weiss, an experienced NSF Program Director. Over the ensuing five years, the response to this new Division has been extraordinary. Distinguished scientists from virtually all fields of science have submitted multi-disciplinary research proposals to this new Division. Research proposals range from theoretical models of human cognition to the design and evaluation of library information systems. The quality of proposals funded has been outstanding and the growth rate of proposal flow has been unusually large. Funding levels, however, have not been forthcoming, and the Division has suffered from cuts in its staff. Two years ago, Dr. Resnikoff resigned to accept a position at Harvard University. Two weeks ago, Dr. Weiss resigned to accept a position in the private sector.

Elsewhere in the Foundation, organizational issues that relate to the general area of Computer and Information Science and Engineering research continue to surface. In January 1983, a workshop was convened at Leesburg, Virginia, consisting of working scientists and NSF staff, relating to all of these areas of research. From that workshop has emerged a comprehensive report that describes the depth and breadth of research problems relating to computer and information science and engineering. Although this report does not suggest organizational reform per se, it is a blueprint for research problems in the field. That report, titled Report of the Information Technology Workshop, edited by Robert F. Cotellessa, sponsored by the Directorate for Engineering of the National Science Foundation in collaboration with the Department of Defense, October 1, 1983, should be a part of this record.

It is my recommendation that a special panel be appointed and convened under the auspices of the National Science Board to examine the question of organization for the research programs connected with Computer and Information Science and Engineering in the Foundation. The question should be examined with the objective of determining the most effective structure for research and the dissemination of research results, whether it be the present structure or some new arrangement. Computer Science was recently established as a separate research division in the Foundation, an important step, but the effective linkage of research programs in the Foundation is an evolving set of phenomena, and it is an important time to consider both the organizational structure and the funding of these most important research areas.

Mr. WALGREN. Well, I appreciate that testimony. It is very direct and you have anticipated, or perhaps we anticipated, your thrust in some areas that the committee has been concerned about. We would be very interested to know directly how your recommendations of a review in that area are received at the Foundation. I think it would be helpful if we could have whatever the background presentation that you used to argue for that committee might be.

Would that be put on paper—and I am thinking particularly you were talking about a—asking for a new group to review the wide range of computer and information processing efforts of the Foundation; is that correct?

Mr. WYATT. That is correct And this is, by no means, a punitive review of any sort. It is simply that we are in an area that's evolving extremely rapidly. We know that we have some new issues; namely, the management of these resources for science research—and some old ones; namely, the levels of funding and the staffing at the Foundation in the areas of program direction.

Mr. WALGREN. When a proposal is made to the Foundation for that kind of review, is that a proposal that is individually initiated by yourself, or does it come from—you mentioned an ad hoc committee in this area.

Mr. WYATT. The ad hoc committee that I referred to is a committee that is now operating to deal exclusively with the question of the management of supercomputer resources. That is, we are going to make recommendations to the Foundation on the type, number, the budget for super-computer resources.

As a part of that, we need also to make some recommendations about how those resources are organized and managed. I think that in addition to that, another group, a group that involves a subgroup of the National Science Board perhaps, and others, take a larger view of the Foundation's work in the general area relating to computer science, information science and engineering, and all of that research activity that exists in several different parts of the Foundation, to see if it might be beneficial to revise the structure, the organizational structure of those programs.

Mr. WALGREN. Is that a proposal that has been formally made to the Director of the Foundation?

Mr. WYATT. Actually, one might consider that it is in work and under way. I would like to put some edges on—a bit of definition—on one of the reports, the report that I cited on Information Technology Workshop edited by Robert Cotellessa. That group was convened in Leesburg, Va. It consisted of all the program directors in the National Science Foundation that host research related to the area I am describing. It included several dozen researchers, people who actually perform research in the field, and it was a session in which we explored the breadth and depth of research problems that relate generally to computer information science and engineering.

So I think in a sense the background work for this effort is underway both in the ad hoc committee on supercomputers and the prior committee that actually was stimulated by Dr. Sanderson, who is no longer at the Foundation. So I just hope that I can stimulate this activity to be picked up again, to be recast a bit, expanded a bit, to include issues like the supercomputer resource management and a comprehensive plan developed.

Mr. **Walgren**. I know many on the committee would like to encourage you in that. I am fishing for some way that the committee can be directly aware of the needs that are presented to the Foundation, the considerations that are presented to the Director, because we want to both look at them ourselves and try to add weight to those that find a responsive chord from a public policy standpoint.

And so what I guess I am asking is that if a request is made of the Director, we would like to be copied in, and particularly copied in on the arguments that are made for the request, the points of need that are cited, and the documentation or the backup—not voluminous in detail, but at least enough so that the committee is aware of the direct concerns that are presented to the Foundation. And we trust the Foundation will be reading your testimony here today and, I am sure, picking up on the threads of that.

But the committee would like to have any written submission that you make to the Foundation for our consideration, and we want to talk to the Foundation about how they respond to that kind of request made of them.

Mr. **Wyatt**. I would be pleased to do that.

Mr. **Walgren**. Is the Advisory Committee on Information, Science, and Technology of several years ago—does that still function?

Mr. **Wyatt**. No; it doesn't. It was discontinued about 9 months ago and replaced by an overarching committee for the whole Directorate of Biological and Behavioral Sciences.

Mr. **Walgren**. We had a couple of questions we were wanting to ask you about whether or not the institutional arrangements at present seem to you to be the most helpful. Clearly, the answer is no—and not to put words in your mouth—but you are looking for some future suggestions to be made by a representative body of proper expertise in that area.

Is that correct?

Mr. **Wyatt**. That is correct. Given the events of the last 5 or 6 years, I believe it is time to look at that issue again in a much more comprehensive way.

Mr. **Walgren**. And you are very direct in your testimony of the fact that the $20 million initiative really is not going to do what needs to be done, and that it will essentially prevent or leave unaddressed a number of needs in the social sciences in particular.

Mr. **Wyatt**. I think that is right. It is not that $20 million wouldn't help. Anyone, I think, would say that additional moneys can be used well. But in order to really treat the problem and to even begin to catch up significantly, it is going to take a bolder step.

Mr. **Walgren**. And you have a recommendation for $100 million; and that recommendation will be broken down in its components. And——

Mr. **Wyatt**. Yes.

Mr. **Walgren**. And we would be able to see what you would get with the additional increments?

Mr. **Wyatt**. Yes; as nearly as we can forecast it. That is our objective.

Mr. **Walgren**. Well, we would be most anxious to have that to work with and to educate ourselves on. If there is any way that the breakdown of that $100 million could perhaps be done incrementally so that we could understand what would happen if we got an additional $50 million or we got an additional $30, or we got an additional $75—what the best use of each would be.

Mr. **Wyatt**. We will try to consider several levels.

Let me say, again, that it is my personal view that the highest level is very, very important.

Mr. **Walgren**. It is relatively unusual for U.S. scientists to go abroad for facilities in an area like this. Is that——

Mr. **Wyatt**. Well, there are some specialized facilities; that is, facilities like an accelerator that might not be available anywhere else in the world. But I find it unusual that American researchers would go abroad to use an American computer that they can't get access to in this country.

Mr. **Walgren**. Well, that sure is a warning sign that we ought to take a real measure of, and hope that we can keep our capacity coming on as strongly as it should come.

Let me turn to the minority at this point.

Mr. **Skeen**. Thank you, Mr. Chairman.

I have no questions. I am sure that you have covered the material very well in your usual fine fashion.

I apologize for being a little late, but things were running a little slow today.

Thank you very much.

Mr. **Walgren**. Are there any other subjects that our staff would like to raise on either side? Does the minority counsel, Ms. Maryanne Bach, have a question?

Ms. **Bach**. Mr. Wyatt, you previously mentioned the difficulty or the fine point with regard to supercomputers, that adequate staff, technical staff, needed to be at various centers; and some of the argument that we had heard from the administration in terms of not being overly aggressive with regard to the Foundation was the concern that proper technical people had to be trained, had to be placed at university centers, had to work with national laboratories, in order to really understand what was involved in the networking.

It seems to me that you are saying that this can still be done at a level of $188 million?

Mr. **Wyatt**. That is my belief. I believe that it is true that those resources are scarce, but we have some research computer facilities in this country of long standing. Many of them were established by NSF support in the middle sixties. And it is my belief that by those groups working jointly with the national laboratories, adequate staff can be developed to initiate this kind of level of services.

Ms. **Bach**. Within a year's time?

Mr. **Wyatt**. We are talking, you see, about the allocation for fiscal year 1985, so it is not a year from today; it is more than that. And I really do believe it can be put together very quickly.

I am encouraged by the work that we have done in this panel that meets next week, and I am encouraged to believe that we can put together resources at that level of support.

Ms. **Bach**. How do you see the networking system being set up?

Mr. **Wyatt**. Well, of course, we have in this country now a large number of networks that have been established for the right reasons, to deal with specific issues. The ARPANET was an early on. When I was chief executive officer, we established EDUNET, serving 400-plus universities. These are separate networks. So one of the first steps is to derive a methodology that will allow the interconnection of these networks.

The second step in that would be to augment those networks as required to provide special channels of communication if they are necessary for access to supercomputers by specific users. In other words, that question—it may be that there will be some requirements of that sort. I believe we can make that determination rather quickly.

Ms. **Bach**. When you do provide the analysis of the incremental increases to the Foundation for the funding of supercomputers, could you be specific enough to include how many front-end requirements would be needed for this networking system as opposed to actual hardware, supercomputer hardware, at a center? So, we are talking about the necessities for outlying or surrounding universities, and we are also talking about the requirements of a center. And it would be, I think, important for the committee to have a clear idea of what is necessary for tying in, and then what is necessary for that particular center.

Mr. **Wyatt**. I think you are right about that. That is one of our categories, one of five or six categories to describe the budget. And I think it might even be useful at some point for members of this committee to actually visit and see the kind of equipment that we are describing, because it makes so much difference in the use of the supercomputer resources that without these front-end systems the supercomputers are essentially diminished enormously in their usefulness.

Ms. **Bach**. Maybe you could make a suggestion as to where the appropriate place would be for us to——

Mr. **Wyatt**. I think we could do that.

Ms. **Bach**. Thank you.

Mr. **Walgren**. Thank you, Ms. Bach.

Any other thoughts?

Mr. Brown?

Mr. **Brown**. I don't have any thoughts right at this moment, Mr. Chairman.

Mr. **Walgren**. I think I had better rephrase that question.

Mr. **Wyatt**. I know better than that, Mr. Brown.

Mr. **Walgren**. Well, thank you very much, Mr. Wyatt. We really do appreciate the directness of your testimony. It is very helpful, and we are subject to confusion. When somebody comes up and tells us exactly where the needs are and how they should be addressed, it is very helpful. And we look forward to the submissions following out of your testimony.

Mr. **Wyatt**. Thank you very much. And thank you for your kind attention this morning.

Mr. **Walgren**. We want to welcome Ron Flippo, a former member of the committee, who had to leave the committee under the rules of the House in order to serve on the Ways and Means Committee.

For those who aren't insiders in the House of Representatives, all Members of Congress are equal. But, as in most societies, some are more equal than others. Service on the Ways and Means Committee is deemed to be more equal than many others and, therefore, those Members are asked to serve only on that committee and they have to give up previous assignments.

So Ron has had a continuing involvement from Ways and Means on issues related to science and technology, and we really appreciate your interest in these areas and the cross-fertilization that we can cause to happen by your membership on Ways and Means.

So welcome back, and please proceed in any way you would choose.

STATEMENT OF HON. RONNIE G. FLIPPO, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ALABAMA

Mr. FLIPPO. Mr. Chairman, I deeply appreciate the kindness of your remarks, and I share your view that there are no more important areas than the area which you and the members of your distinguished committee serve, and I share that view with you.

I am extremely pleased to have the opportunity to testify before you today. As a former member of this subcommittee and this full committee, I deeply appreciate the work and the leadership that you and the other distinguished members of this committee are providing in developing national goals and policies and programs to maintain the leadership of our country in science and technology.

This morning I want to speak briefly in support of one area of the National Science Foundation budget that concerns me. For some years, Mr. Chairman, I have been interested in seeing a wider development of scientific talent and of centers of excellence across the country, and perhaps a more equitable distribution of Federal funds to support the development of those programs. The awarding of Federal grants on the basis of quality and technical merit certainly demonstrates that the funds will be spent only on first-rate research.

I think that is a sound policy that insures that the investment of the Federal revenue will yield the highest returns, but I think, in addition to that policy, that we must recognize that that policy also tends to perpetuate the uneven distribution of research capability throughout the country. Of the total Federal budget for fundamental research spent on college campuses, the bulk of the funds are distributed to those campuses in the States with the highest level of funding. For example, this year 60 to 65 percent of available Federal research dollars have been allocated to campuses in 10 States where the support for higher education is the highest, while only 1 to 2 percent went to schools in the 10 States where funding is lowest.

The National Science Foundation has, I think, at the urging of the chairman and other members of this committee, and others, given some attention to this problem. For the last 5 years, NSF has been operating the experimental program to stimulate competitive research, EPSCoR. This program was designed to, one, increase the capability of scientists and engineers in States that have been relatively less successful in competing for Federal R&D funds; and to, two, encourage a wider distribution of scientific talent and Federal funds.

Under this experimental program, NSF awarded $2.5 million to $3 million each year from fiscal year 1981 through fiscal year 1984 to universities in five States that were among the lowest in total Federal research funding. The awards were made to help support statewide research improvement programs, and the five States chosen were Arkansas, Maine, Montana, South Carolina, and West Virginia. The experimental program is scheduled to end this year, and is not included in NSF's budget request for fiscal year 1985.

Mr. Chairman, a report by NSF in October 1983, midway through the program, showed that while the change in the rank order of States participating in the experimental program was not dramatic, a number of results were noted. These include: that the quality of the faculty in participant institutions had been improved; that over one-half of the 183 EPSCoR-supported scientists had already received other Federal awards; that interaction between scientists in participant States and nationally recognized scientists had increased significantly; that participant scientists were getting increased exposure, and research productivity had been increased; and in all participating States, internal communication between the scientists, administrators, legislators, and the community had been improved.

In a recent Science magazine editorial, Prof. Gary A. Strobel, who has directed the program at Montana State University, highlights a number of achievements made at his university under the program. He states that well over 50 percent of the original investigators have acquired extramural research funds from Federal, State, and private organizations and agencies—in amounts which nearly double those originally received from NSF. Dr. Strobel says that after NSF funding has ceased, that the program will continue with State funding.

Looking at the record of what has been accomplished with a relatively small investment of funding under this NSF program, it seems to me it is an emphasis worth continuing.

I feel this is important not only because it enables these less-than-top funded institutions to compete for Federal research dollars, but because it enhances our total research base, it improves our undergraduate education in science in these locations, and it provides better graduate education.

It seems to me, Mr. Chairman, that in these times, when our Nation is struggling to keep its leadership in science, high quality centers of excellence need to be encouraged in all areas of the country and scientific talents developed and used wherever they are available.

I believe the success of the program warrants committee support, and I urge the subcommittee to reauthorize the program.

Mr. **Walgren**. Well, we certainly appreciate very much your coming and stressing that with us in this record.

Did they do anything along this line before that 5-year program was started, or did it start at that point?

Mr. **Flippo**. I am not certain the extent of their efforts. For many years, I think, they had some type of program of trying to develop and improve the centers of excellence. But there has been very little variation in the allocation of the NSF funds among the States over the last 4 years. I think a review of NSF trending funds from 1977 through 1982 shows that only 13 different States were ranked among the top 10 at one point or another.

The top five States of California, New York, Massachusetts, Illinois, and Pennsylvania held the same exact rank over this period of time, and the trend among the bottom 10 or 15 States shows a similar degree of stability. These same States have consistently ranked among the bottom 15 over the past 15 years, and I would hope that NSF could concentrate their efforts to some degree in improving the ability of these States to compete for those funds.

Mr. **Walgren**. It certainly makes sense to me in that it strikes me that we ought to have some effort that looks for ideas very broadly, and that many ideas that have been major scientific concepts and led to very fruitful pursuit did not necessarily come from the old guard or any of the established institutions. There certainly ought to be some effort made to increase the contact of an organization like the National Science Foundation with institutions that are out there across the country literally. I know that happens to agree, but certainly it is something we ought to institutionalize and reach out for.

Are there others—the Chair would recognize Mr. Brown.

Mr. **Brown**. Ron, you have been aware from your service on this committee that there has been a certain tension for a number of years over this concept of distributing research grants on the basis of some geographical equity versus on the basis of seeking to put the money where the highest quality of research was being done; and it was a result of this tension, I think, that led to development of this program, which I personally support and commend.

I think it was an excellent program in the sense that it takes the emphasis off of the issue of one of geographical distribution versus quality to one of improving quality wherever we may have the opportunity to improve it. I think we can all wholeheartedly support that kind of approach to the problem.

One question comes to my mind, and that is I note that this year the administration is supporting an increased funding for the NSF to establish centers for fundamental engineering research and that this may be an expanding program in which institutions around the country will be supported and encouraged in improving the quality of fundamental—the term "fundamental engineering research" is used as an equivalent to basic science research—and I think it could conceivably be as important or more important to the economic future of the country than the basic science research.

Do you happen, from your knowledge, to be aware of whether this might be considered by the administration or the NSF as in some way a substitute for this program to stimulate competitive research?

Mr. **Flippo**. Mr. Brown, I am not aware of the feelings of either the administration or NSF with regard to that.

Mr. **Brown**. They don't consult with you?

Mr. **Flippo**. No, unfortunately. I am sure that with the assistance of my friends on this committee, that we could give them some good advice with regard to that. But they have not consulted with me in regard to that.

I know this committee has been concerned about the education of engineers and has sponsored in the past legislation in regard to that. But I don't have any particular knowledge as to how they view——

Mr. **Brown**. Well, it seems to me that for the limited amount of money involved in the program to stimulate competitive research, it would be well worth continuing, and I would personally support it. But, as you well know, we have to make these decisions about whether we encourage the administration to support good ideas by adding authorization to do that to the bill, but stay within their budget limits, or add it on in addition to their budget limits. And both ways create certain problems for us here. But I think we will solve them one way or another.

Mr. **Flippo**. Thank you.

Mr. **Walgren**. Thank you, Mr. Brown.

Mr. Skeen.

Mr. **Skeen**. Ron, that was good testimony to the kind of improvement of a program, and I couldn't agree with you more; that I think that that base needed to be broadened insofar as the centers of excellence and so forth.

Speaking of the administration—not answering for them—but we questioned Dr. Knapp the other day specifically: Do you have to belong to the good old boy network to get funding out of NSF for various projects? And I think that he was delighted to answer—and he maybe even planted the question; I am not sure.

He answered, "Certainly not," and that they were doing everything they could to build on the success of the program that you have been talking about, to make sure that there isn't a good old boy network working. I think that is progress in itself, because if you are going to have this kind of an interest in fundamental engineering research—and I was very interested, too—we had testimony at another committee yesterday by some of the so-called pure scientists, the chemists and the physicists, and some of the rest who for years have viewed engineering research as something aside and not belonging to that discipline—and I think that if we are going to excel and if we are going to compete, we have got to inculcate all these branches of science and quit deciding whose ivory tower is whose.

I think that allocation of these funds in the manner that you talk about is a very progressive step and good progress, good results.

Mr. **Flippo**. I thank the gentleman from New Mexico for his remarks.

Mr. **Skeen**. We appreciate your interest, too.

Mr. **Walgren**. Mr. Boehlert.

Mr. **Boehlert**. Thank you for your testimony.

Obviously, it is very evident that this committee is very supportive of the program.

Mr. **Flippo**. Mr. Chairman, thank you very much for letting me appear.

Mr. **Walgren**. We appreciate your coming, and we will see you soon.

The next witness is Dr. Robert Kersten. Dr. Kersten is the dean of the College of Engineering at the University of Central Florida.

Dr. Kersten also chairs the engineering education task force and has been very active on a national level in this area.

We particularly appreciate your coming in view of the discussion of the committee over Mr. Brown's proposal and a general feeling of real inadequacy in our addressing the engineering component of the development of our capability. And so we really do welcome your testimony. And, again, written testimony will be made a part of the record for the study of all those on the committee and others interested, and so in your oral testimony we would be most pleased if you would highlight the points that you feel are most important and communicate them to the committee in whatever manner you feel is most effective.

So, welcome to the committee.

[A biographical sketch of Dr. Kersten follows:]

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DR. ROBERT D. KERSTEN, P.E.
Professor and Dean, College of Engineering

Dean Kersten is a native of Illinois and has received his Bachelor's degree and Master's degree from Oklahoma State University and a Ph.D. from Northwestern University. He has served on faculties of Oklahoma State University, Arizona State University, and now the University of Central Florida. His industrial experience includes duty with: Flight Safety Foundation, Jersey Production Research Company, Carter Oil Company (now Exxon), U.S. Department of the Interior, and A.E. Staley Manufacturing Company. Dean Kersten has been named to many honors, awards, and biographies including Who's Who in Engineering, Who's Who in the South and Southwest, American Men of Science, and Sigma Xi, and is the author of numerous publications. Long active in various professional societies including ASEE, NSPE, ASCE, and AAAS

Dean Kersten currently:

- Chairs the Engineering Education Task Force (EDC, ASEE, NSPE and NASULGC)
- Chairs the Florida Deans of Engineering
- Serves on the Florida Board of Professional Engineers
- Represents the National Council of Engineering Examiners on the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology
- and is

Vice President-elect of the National Society of Professional Engineers

STATE UNIVERSITY SYSTEM OF FLORIDA AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

STATEMENT OF DR. ROBERT D. KERSTEN, P.E., DEAN, COLLEGE OF ENGINEERING, UNIVERSITY OF CENTRAL FLORIDA

Dr. KERSTEN. Thank you, Mr. Chairman, members of the committee. It is my pleasure to be here.

You have received our written statement. And having heard some of the comments this morning and testimony earlier yesterday, I think our remarks are more pertinent and more on target than we could have hoped they might have. I think we are right close to the concept that is extremely critical in its importance to the continued development of innovation and creating new technology, putting this country back in first place in the international marketplace.

I think the missing link is fundamental engineering research and all its ancillary matters. We have always stressed the basic sciences. That is appropriate, should continue, should be strengthened.

Industry in this country has done a beautiful job in the main of doing applied research and development, product development, commercialization and so on. But we are running out of the fresh new ideas and innovative, creative technology matters that should flow from a strong engineering educational system, including those areas of fundamental engineering research that I think Mr. Skeen and Mr. Brown had in mind.

Let me emphasize then our written statement. We will point out a couple of matters.

Second, the task force I represent is composed of membership from the American Society for Engineering Education, the National Society of Professional Engineers, the Engineering Deans Council of the United States, and the National Association of State Universities and Land-Grant Colleges. That latter association represents about 60 percent of the degree productivity in engineering in this country, a very effective body.

The deans council—I have been in the deaning business approximately 16 years, and I think this issue for the first time has united the deans in trying to make strong statements to your committee and others about the status of engineering education and the perceived importance to our national welfare.

As was pointed out by Dr. Harrison yesterday—and we totally concur—this process should be emphasized, the process of innovation. There is basic scientific research, fundamental engineering work, applied R&D, and product development. A whole spectrum of things must take place. And we maintain that this segment of fundamental engineering research is lagging. There is a gap there. And we think the place to strengthen that is within the National Science Foundation.

The National Science Foundation currently has given some renewed emphasis to engineering, but that has not always been so. And back over the years engineering, quite candidly, has been treated just a little bit as an appendage rather than a full partner in that organization; and that is not meant to be critical of any of the leadership of that body or the National Science Board.

You understand the legislation creating the Foundation emphasized basic scientific research, and to too many people, when you suggest engineering, you immediately suggest applied, which is something basic scientists abhor, if you will. I think we have to get over that feeling and get back to the situation where there is a close link between basic scientific work and fundamental engineering work, and the place to do that, in our view, is in the National Science Foundation.

We are pleased to commend Mr. Brown and Mr. Skeen for their leadership in this issue and sensing the importance of this matter by introducing a bill before your body, and we think that it is a concept that is just right on the target. We must differentiate between what is science and what is engineering. There are some very close linkages, but there are some very great differences.

Scientists investigate phenomena, as has been pointed out many times. The minute they move over into finding applications and uses for that phenomena, they are doing engineering work.

There is a function called "engineering" that must be performed in translating known science, known phenomena to some useful purpose, which is our end result—improvement of quality of life of all of our citizens in every sphere, in every segment of industry.

In that regard, one of your presenters yesterday suggested a great diversity of engineering, and we should understand that—for so long within NSF engineering has been one division or now a directorate trying to represent some 40 different degree fields within engineering. Engineering is as diverse as the alphabet, and getting more so as basic science expands its horizons in looking into new areas, which you will probably hear more about this morning. From the small to the very large concern, it is pervasive; it is everywhere.

Our modern way of life is a result of good fundamental engineering work, and it is lagging right now. We are competing in a world marketplace, and we are losing, gentlemen, as you well know. Engineering cannot be treated as just a single monolithic thing and put off in one corner. It has to be seen in a more pervasive overview, and there hopefully will be engineering/technological applications of every fundamental scientific phenomena that we discover and that we learn about. I think that is where the action ought to be.

The budget proposals before your committee have to be considered as exciting. The increases in the several directorates, including engineering, the crossdisciplinary research centers, hopefully the restoration of this competitive research item that was just mentioned by Congressman Flippo, and so on—it just is exciting. That is all that can be said.

How can you be against motherhood and the American flag? Although, as pointed out by Dr. Wyatt, there are certain segments, if you intend to achieve progress in certain areas of technology, the investment has to be very large. And we believe this is a situation where—for example, the 1984 budget, engineering was 9.1 percent of the National Science Foundation budget. Even with the suggested large percentage increases, engineering will only be 9.8 percent in 1985, assuming congressional approval.

The total increase of all the various directorates doing research work is about $140 million. The absolute value of the engineering proposal is $147 million. So the increase in the science budgets alone is about equal to the total suggested amount for engineering.

Now, we think that must change, and we think NSF must arrange itself organizationally to accommodate this anticipated continued growth curve. It is important to the welfare of our country. Now, that has always been true, we suggest.

I would like to introduce for the record, Mr. Chairman, a letter our committee has received from Dr. Ralph Morgan. Dr. Morgan was in 1950 the first director of the engineering branch, or section, or division, or whatever it was called in those days, of the National Science Foundation. When he learned of our work, he wrote to us about three specific examples that his section was called upon to fund but which the then leadership of the Foundation suggested was not basic enough to be included within the Foundation. Those three ideas—two of those ideas were, of course, very current then. One is a newer one in date and time.

The first related to the use of transistors in electronic circuits. Nobody thought the National Science Foundation of that era should have any concern over that matter, which seems strange to me in view of the subsequent developments of technology in electronics and computers flowing from that.

Another was reforming of certain petroleum products and the need for certain kind of catalysts in chemical engineering and chemistry, and nobody thought that was fundamental enough for the Science Foundation to undertake. And yet, out of that very work came the substitutes for all the lead that was in gasoline and the movement to unleaded gasoline, which helped us correct an environmental problem.

It seems to me that is a very fundamental activity that should have been within the Foundation and not forced to be elsewhere. He is suggesting similar processes ought to be going on today within the engineering community dealing with the chemistry and the apparatus needed to cure some of the smokestack problems that lead us to acid rain situations.

It is a similar phenomena which he was talking about 30 years ago. That sort of thing has been our way of life. I guess most of us are used to living with presidents and vice presidents like the ones who testified before you yesterday who didn't think that anything so dirty as engineering fundamental work should be included within the sciences. We think you need to do everything you can to encourage the linkage rather than try to divorce it from that activity.

I would suggest, further, Dr. Vannevar Bush, in his report in 1945 to President Truman, suggested a National Research Foundation, a National Research Foundation to do work which was fundamental to the military, our national defense, and the public welfare. What we have is the National Science Foundation, which is doing all the basic scientific things essential to our national welfare, but we are not doing, I think, the broad spectrum of things Dr. Vannevar Bush envisioned for our total welfare, which would include fundamental work leading to technological innovation, the international competitive problem and so on that is before us in this era.

Finally, it is very important that we understand the link between this process within the National Science Foundation—sciences and engineering and education. The most critical element, in our view, is the improvement of the quality of the engineering talent pool. We cannot expect a world-class performance out of American industry if we are not producing world class graduates from our engineering and science schools.

In the engineering community, you have heard of all of our problems of the shortage of faculty, the lack of graduate fellowships for American citizens, the laboratory equipment problems, et cetera; but those are very key. If we expect absolute top-notch professional practice of our professional engineers, we have to give them top-notch educational preparation. And I believe our American industry suffers somewhat because it does not have—it is not able to recruit in the numbers and quality of talent that it really ought to have to compete in this international race.

So, in closing, Mr. Chairman, we believe the concept envisioned in H.R. 4822 is an extremely important one and worthy of your support. It may even be a critical step that has long been overlooked in our society, and it may well be the concept that could provide a focus for all the discussion that has gone on this session and last session about innovation, international competitiveness, international policy, and so on.

I believe it is time for the engineering profession to have a home in the Federal sphere. In our case, we believe it should be within the National Science Foundation and that we ought to encourage that in every way possible.

Thank you, sir.

[The prepared statement of Dr. Kersten follows:]

STATEMENT OF

DR. ROBERT D. KERSTEN, P.E.

DEAN OF THE COLLEGE OF ENGINEERING

UNIVERSITY OF CENTRAL FLORIDA

Chairman Walgren and Members of the Subcommittee:

I am pleased to respond to your invitation to discuss institutional arrangements for engineering education and research and share some views on the FY 1985 budget request for the National Science Foundation. While the views expressed here are my own, I have the very strong support and concurrence of the Engineering Education Task Force consisting of

> Dr. Robert D. Kersten (University of Central Florida), Chairman, representing the National Society of Professional Engineers
>
> Dr. Robert H. Page (Texas A&M University) representing the Engineering Deans Council of ASEE
>
> Dr. W. Edward Lear (Executive Director of ASEE) representing the American Society for Engineering Education
>
> Dr. Donald D. Glower (Ohio State University) representing the National Association of State Universities and Land Grant Colleges

Collectively, our membership consists of over 100,000 individual engineers from all disciplines and employment areas, over 100 corporate employers of engineers, and about 400 colleges and universities which enroll nearly one-half million engineering students in the United States.

Our task force was formed last spring in response to a request from the Engineering Deans Council, the organization of the nation's engineering school deans. We were asked to develop a long-term legislative solution to engineering education and research problems which could be embraced by the diverse community represented by the group. Early on in our meetings, it was concluded that before we addressed the specific problems of faculty shortages, equipment deficiencies, and under investment in engineering research, we needed to focus on the issue you raise here this morning, that of institutional arrangements to support innovation and research.

This decision was based on one major concern. It is clear that efforts are being made to address specific engineering education problems by the Administration, the National Academy of Engineering, and especially by this Subcommittee. Programs such as the Science and Engineering Personnel Fund in Title II of HR 1310 and the Cross-disciplinary Centers proposed in the FY '85 NSF budget are important steps in the right direction. We applaud these initiatives, but believe they are being developed without proper analysis of the agency that is expected to carry them out. We believe their potency and effectiveness will be inhibited by the limitations of the National Science Foundation. We therefore decided to direct our attention toward these structural shortcomings.

Summary

Before I go into detail on this, I would like to summarize my thoughts for the Subcommittee.

1. Innovation depends on a strong and continuous link between science and engineering. In fact, the boundary between science and engineering research in the innovation process is not a distinct one. It is desirable to keep science and engineering closely linked in the Federal support structure.
2. While some people include engineering research in the rubric of "basic" research, we believe the term "fundamental engineering research" is more appropriate. There is a common perception that science is basic research, and clearly within the Federal domain, while most other research is applied, and therefore the

responsibility of the private sector. This dichotomy is, of course, inaccurate. It leaves fundamental engineering research in limbo, without a clear Federal role. This research generates future technology from scientific knowledge, through investigation of systems, manufacturing processes, materials and methods. It is different than basic scientific research, yet not applied or commercial in orientation. Fundamental engineering research is academically-based, non-proprietary, and generic in nature.

3. The National Science Foundation is currently giving some emphasis to engineering, but without the benefit of a clear mandate to do so. NSF support for engineering has, through the years, been sporadic and at times questionable. This stems largely from the fact that NSF has no clearly stated engineering role in its mission statement. We need to institutionalize engineering within the Foundation, and make it clear that we are committed to producing a strong science and engineering base in order to compete more effectively in world markets.
4. We would like to commend Mr. Brown and Mr. Skeen for their leadership on this issue. Their bill, HR 4822, embraces these concerns in a most appropriate manner, and has our full support. We hope the Subcommittee will consider it favorably.

Engineering and International Competition

It is our understanding that the focus of attention here today is the very great concern for achieving the most appropriate institutional arrangements to support innovation and research. Such support should contribute to improved productivity and real economic growth and, in short, an improved competitive posture for American industry.

Whatever research we choose to do will not be of world-class, competitive quality unless we are able to assure the flow of the highest quality technical talent throughout the innovation process. This process will bring increased benefits to our nation only if all of the partners (i.e., government, industry, and universities) are able to conduct their affairs from positions of strength and exellence.

Our engineering schools are clearly not operating from a position of strength. As the Business-Higher Education Forum recently reported to President Reagan, "Unless the clear inadequacy of the U.S. engineering manpower and education systems is rectified, it jeopardizes the future competitiveness of our nation's technologically based industries and defense."

We know you are well aware of the problems, so will not go into detail here. However, the following facts will be helpful to keep in mind:

- Over the last decade, engineering student enrollments have skyrocketed 115%, while the parallel faculty growth has been a mere 12%.
- The cost of modernizing engineering laboratories is estimated at $1.2 billion, at 1971 enrollment levels. Corrected to 1981 enrollment figures, estimated cost increases to $2.2 billion. This does not even include computing equipment.
- Our major international competitors are producing more engineers than we do. Japan alone educates six times as many engineers per capita than the U.S.

- Engineering accounts for only 7% of the total undergraduate degrees produced annually in the U.S., compared to 21% in Japan, 35% in the Soviet Union, and 37% in West Germany.

Competent economic authorities have concluded that from about one-third to one-half of all the growth in the American economy in the past 100 years has come from technological change. The fact that in the last decade there has been an apparent decline in the rate of technological change is of great concern.

We realize that there are many factors (e.g., international trade policy, economic conditions, capital formation, changing energy relationships, etc.) contributing to these problems which may be beyond the scope of these hearings. Independent of these other factors, however, continued technological competitiveness will depend on the quality of our technical talent and ability to innovate. Without an adequate supply of qualified engineering talent, our strong science base will have a limited impact on our nation's economic well-being.

Federal Role in Innovation

Innovation cannot be forced; it can be fostered, encouraged, or excited. Innovation implies a qualitative change as when some new technology is tried for the first time. This is typically done to improve economic efficiency of a process, to make a superior product, or improve one's competitive position. It may imply a new "system," provide for more efficient utilization of resources, or creation of new products. Innovation therefore involves a signigicant technological and economic risk and certain front-end costs. We suggest that the successful innovation process involves four major steps --

(a) basic scientific research;

(b) fundamental engineering research;

(c) applied research and development;

and (d) commercialization or product development.

One way or another, entrepreneurs, industrial groups, and mission-oriented agencies have carried on (c) and (d), which is entirely appropriate given the proprietary nature of this work. At the same time, the nation's universities, supported in part by the National Science Foundation, are responsible for a significant portion of (a). But fundamental engineering research, (b), which is the link from (a) to (c) and (d), is a weak bridge, without a firm foundation of support either in industry or government.

A Federal role in "basic" scientific research is clearly appropriate. A Federal role in "applied R&D" is commonly accepted in the mission-oriented agencies and the private sector. We concur that there should not be a major Federal role in "commercialization." On the other hand, we believe there should be a Federal role in the area of "fundamental engineering research," which leverages non-Federal participation to the maximum extent possible.

The similarities between science and engineering research are many. The scientific method is applicable to both science research and engineering research. The terms basic and applied research are difficult to define. The same work done by a scientist and engineer may be classified as basic by the former and applied by the latter. Pure research is often used by some as a further subdivision of basic research. To distinguish between science and engineering by separating these functions in different Federal structures would further weaken this synergistic relationship.

Fundamental engineering research is vital to the national welfare and security. Without a definite focus on a specific application, most industries only sparingly support long-range fundamental engineering research. The results of fundamental research are a part of the national wealth upon which all can draw for future use, and should be a function of the National Science Foundation.

The Vannevar Bush report "Science, the Endless Frontier" delivered to President Truman in July, 1945, envisioned a National Research Foundation to execute a program, largely by way of grants to educational institutions, for the conduct of basic research deemed important to the national defense and welfare.

What we obtained in 1950 was the National Science Foundation, whose mission became "basic scientific research." The Foundation has been uniquely successful in fostering scientific progress, and should continue to do so. Yet it has not devoted enough attention to the "general research needs" as envisioned by Dr. Bush. In today's terms, these needs include fundamental engineering research, which is the primary agent in the development of new technology from scientific information. For example, scientific research resulted in the identification of electrostatically charged particles, and then defined their behavior. Engineering research led to the design of systems which took advantage of that scientific information to develop modern photocopying processes.

The major undertakings in the World War II era (e.g., electronics, nuclear energy, radar, computers, etc.) were more engineering than science. Doctoral level engineering personnel were almost non-existent, the National Academy of Engineering had not been founded, and so quite naturally the perceived need was science.

Science and Engineering Partnership

We believe that engineering has come of age, academically and professionally and should be recognized as a mature partner in the innovation process. NSF has concentrated almost exclusively on "basic scientific research" for nearly 34 years. As our nation's growth has become increasingly based on technological progress, our dependence on quality engineering research and talent is greater than ever. Attempts to enhance the role of engineering within NSF nave been limited to date, due in part to the restrictions imposed by the current mission statement. The interplay of science and engineering, which is crucial to the advancement of both and to the development of new technology, should not be hampered by institutional barriers.

In the U.S. nearly all major universities have strong science departments, as well as strong engineering departments. Thus the U.S. academic structure provides a rationale for expanding NSF activities in engineering rather than assigning the support of engineering research and education to some other new or existing agency. NSF has done a very good job in "basic scientific research" and we believe can and will perform equally well in fundamental engineering areas.

Current Trends

We are aware of recent initiatives by NSF to encourage a greater emphasis on engineering research and education. We can only applaud every such step, but it has taken a decade of benign neglect to focus attention on the problem.

The NSF budget request for FY '85 is $1.5 billion, an increase of 13.6% over FY '84. The increase in all research and related activities in all areas other than engineering totals $140.1 million, which is approximately equal to the absolute value of engineering research across all the various disciplines. Further, it is proposed that the Engineering Directorate be increased to a level of $147.1 million or 21.8% over FY '84. The percentage increase for engineering appears impressive when applied to so small a base. However, in FY '84, engineering was 9.1% of the NSF total. With the proposed increase for FY '85, it will become 9.8% of the NSF total. This apparent growth curve is encouraging. Both the direction and volume are appropriate. We suggest, however, that structural changes within the Foundation are necessary to best accommodate this emerging emphasis.

The reactivation of the Science and Engineering Education Directorate is another significant, positive step. It should be noted that two-thirds of the proposed budget is dedicated to pre-college mathematics and science education. The balance will support 550 new and 1,000 continuing NSF Graduate Fellows in all areas of science and engineering. Recent studies by ASEE identified a need for 1,200 Fellows annually in engineering alone, in order to address the shortage of engineering faculty.

The Presidential Young Investigator Research Awards is an outstanding program. However, 100 awards per year to all areas of science and 100 awards per year to all areas of engineering is inadequate. An AAES study recommended support of 500 new assistant professor-level engineering faculty each year for four years.

Efforts to improve research grant awards and other program activities in order to insure improvements in laboratory instrumentation are to be commended. However, no funds are designated for improvements in instructional laboratories, which is where the most critical deficiencies in equipment lie.

Similarly, while efforts are being initiated to address needs in "advanced scientific computing," no movement is detected in bringing undergraduate engineer instruction up to the state-of-the art in use of computing technology.

Conclusion

Our conclusion is that these current trends, however positive, do not go far enough and may not be permanent. There is a need for assured attention to engineering problems over time. There is nothing in NSF's mission statement or name which identifies fundamental engineering research and education as a priority for Foundation support. Instead, as the legislative history of the enabling legislation states:

> "Support for applied reseach...is made permissive and at the discretion of the Foundation...Nevertheless, there are important occasions when Foundation backing for applied research appears warranted...Such research is either inseparable from or is intertwined with basic research, or is a logical extention of the basic research already being supported. This type of applied research is, of course, normal for schools of engineering."

While we in no way believe support for engineering should detract from or be supported at the expense of basic science, we do believe that a stronger commitment to engineering is appropriate to the Foundation's mission statement. Foundation backing for fundamental engineering research is warranted on more than "important occasions"; it is essential to our nation's future health and technological leadership. We cannot afford to have this commitment based on executive decisions, vulnerable to political tides. The National Science Foundation should provide the institutional framework to support engineering, and thus innovation, within the Federal structure. A legislative mandate would certainly enhance the ability of NSF to meet this objective.

Recommendation

We would like to urge the Subcommittee to support legislation introduced by Mr. Brown and Mr. Skeen to accomplish the objectives discussed above. H.R. 4822 is a responsible, effective and viable solution to the weaknesses in our institutional arrangements supporting innovation and research.

H.R. 4822 would amend the NSF mission statement by extending the authorized functions to include fundamental engineering research and education, change the name to the National Science and Engineering Foundation, and make other modifications in the governance structure to reflect the Foundation's emphasis on both science and engineering. Mr. Brown and Mr. Skeen are to be applauded for their outstanding leadership on this issue.

Mr. Chairman, I would like to thank you and all your colleagues for raising this important topic. This Subcommittee has made tremendous contributions to our nation's science and technology policy over the years. I would be pleased to answer any questions, and offer you the full cooperation and assistance of our Task Force as your work progresses.

Mr. **Walgren**. Thank you very much, Dr. Kersten.

Mr. Brown.

Mr. **Brown**. Thank you, Dr. Kersten.

I think I stole some of your ideas in the discussion we had yesterday with regard to the role of engineering and its relationship to science. We had some discussion—I don't know whether you were present at the time—with regard to the developments in World War II which you mentioned in your statement, and I have just about convinced myself that that was a triumph—that our great successes there were triumphs of engineering rather than basic science, although we converted basic scientists to engineers for the purpose of rapidly developing the kinds of products that we needed to meet the exigencies of national security at that time.

This committee has been grappling for years with the concept of how to bring about a proper balance in the support that we give to these various phases of what you call the innovation process; and I think it is correctly named. One of the results of that committee deliberation—and in recognition of the importance of considering engineering and technology as full partners with basic science in meeting national needs, was our action in creating the Office of Science and Technology policy. We didn't create an office of basic science policy or basic research policy; we created an office of science and technology policy, hoping to focus on the whole range of activities that are necessary for the national welfare.

Of course, in the mission area such as defense, we have a separate operation in support of science and technology which doesn't make the artificial distinctions that the National Science Foundation makes. The Defense Department supports basic research and then it supports the further development of technologies and engineering stemming from that basic research where it appears that it may be promising for the mission of the Defense Department.

We don't have anything similar to carry on in that area which has been carved out by the National Science Foundation to support. If there are promising ideas developed there, we assume that they will lie on the shelf until some entrepreneur comes along and sees the commercial possibilities, and that is the gap that we are trying to fill in our effort to restructure national policy here.

I am going over this just so that I can clarify my own thinking, and I will ask you to comment on it. We had some discussion yesterday from several witnesses, most of whom shared your views. But Dr. Rosenzweig, representing the research universities, took a rather dimmer view in contending that this change in the National Science Foundation was not necessary and that it was divisive, actually.

I think I ought to ask you, for the record, if you would comment on the posture that he took—and I don't want to develop a fight here. I want to clarify ideas, more than anything else, and see what you would say in rebuttal to the kind of views that he expressed. Could you do that?

Dr. **Kersten**. You sort of put me on the hot seat, but yes, I will.

I think most engineering deans would view his remarks from the context in which he made them.

Mr. **Brown**. Remember, he is a political scientist.

Dr. **Kersten**. That is the very issue. You understand that there are so few engineering presidents at major universities in this country that most of us are used to living with that thinking day after day after day. There needs to be a greater and broader understanding of the mission and role of engineering in our life, which I think many of the folks, as represented by Dr. Rosenzweig's views, do not have and things are not just basic science and industry.

There is an important place for the practice of engineering within industry and private practice in the Government sphere and wherever, and I think you are right on target. You should seek innovation, the work of your committee and OTA and other boards has clearly shown that the bulk of the economic growth has been derived from the smaller industries and firms, and, that being the case, the emphasis on the engineering talent pool becomes extremely important.

The big companies probably don't have as much of a problem. They can outbid everybody else. But the flow of these one- and two-man firms, so to speak, if it is a company with only half a dozen engineers, it is critical that they have the best possible, or their company is not going to thrive and we need to seek a broad base in all areas of engineering.

We will take innovation from whatever quarter it comes. I don't think any big institution or any one big industry has a lock on innovation, and we urge your committee to kind of take that position also. We should not be apologetic because a great idea happens to come from Podunk rather than Boston, no offense, please.

Mr. **Brown**. Well, I have had some problem in grappling with these efforts to create a better institutional framework for these things because I don't think there is a strictly institutional cure for the problem that faces us. I think the cure depends upon a better realization of the connection, the inseparable connection as a process between basic research, fundamental engineering research, applied research and commercialization that you have laid out in your statement.

And I don't think we perceive that clearly, and we have artificially tried to separate the different ideas, and there is no real basis for that. A better solution would be to have high in the executive branch, hopefully in the President, an awareness of the importance of this and a willingness to cultivate the entire process to make sure there were no weaknesses, so that our whole national resources could be geared to achieving national goals in the best possible way.

But lacking that, we do have to try and improve the institutional arrangements, and that is the basis for some of these efforts that we have been suggesting. As you know, not only do we have the legislation that you referred to that Mr. Skeen and I have introduced, but I have at least a couple of other alternative proposals which I hope to encourage some thought about without necessarily assuming that they were the final answer here.

I don't know what this leads to except at least on my part, I very much appreciate the contribution you have made to clarifying this web of activities, which I think is the necessary foundation for any action that we take.

Dr. **Kersten**. Thank you, sir.

Mr. **Walgren**. Thank you, Mr. Brown.

Mr. Skeen?

Mr. **Skeen**. Thank you very much, Mr. Chairman.

Dean Kersten, I want to extend my thanks to you for the support that you have given the bill and the interest. I think you couched it in the right terms, we give up our perceptions and concepts very slowly. They become traditional. I think we have long since passed the time when so-called basic science lived in a sterile world of its own and anything that emanated from outside that particular area did it by osmosis.

If this country is going to progress, and I think that I concur wholeheartedly with Mr. Brown, that these phase-ins of how we handle our science and technological advances, we are going to have to give up all the old ideas that we had and learn to use the newer concepts.

Amongst them is breaking down these small artificial barriers that really are very large in effect, and the kinds of situations that they produce, and I noticed in the hearings that we had yesterday that those persons who consider themselves more the basic scientists give up very slowly.

They are willing to say that engineering is an integral part of a science, but we don't want to change the name of something. We are going to still hold onto the purity of the name. We are going to give up the idea, though, that it should not be included in some of the programs, so it dies slowly.

But I want to thank you for the support that you have given our efforts, and I am, right along with Mr. Brown, going to do everything that I can to help overcome some of these old perceptions and concepts and get us moving, because we are deficient in this area, and I think largely due to a lot of artificial thought barriers that we have applied for so long.

I think you have a good handle on it. If it comes from Podunk and it is a good idea, we want to use and develop it. If we have superbrains from somewhere, even if from Boston or wherever, we would like to get together on a common basis and help further the goals of this country. I think that is our major objective.

So thank you for your support.

Dr. **Kersten**. Thank you, sir. We feel that a suggested name change is one of those critical concepts. We realize the sensitive nature of it, but I think it is important that the world understand the engineering role and mission, and that it is important. We are not suggesting a separate Institute of Engineering. We live and work close to the science community, and we probably ought to stay there, that is our view, but I think recognition in name is very important to help break down these barriers.

If I may, Mr. Skeen, Mr. Brown, in the earlier days when you were considering OSTP, I believe there was a great debate at that time as to whether it should be OSE or something instead of OSTP, so that issue has been boiling for these many years.

Mr. **Skeen**. One thing I would like to emphasize before I withdraw from this discussion is that you said it well when you mentioned that engineering is such a diverse science in itself. I think we have got the idea locked in our traditional concept in this country that it involves several small areas and so forth.

It does not any longer. Engineering itself is as broad as the whole scientific field, the whole spectrum. It has to be, and I think you did a very good job of pointing that out. That is one of the perceptions that we have to change as well along the way.

Dr. **Kersten**. Thank you.

Mr. Walgren, if I may, an item that appeared in my local paper in Orlando which came from Houston discussing the research leading to the development of the backpack that was used in a recent space shuttle mission, which I am sure is of some interest to your committee. The gist of the story is the research started in 1961 as an engineering master's thesis and has since been picked up by NASA and brought to fruition, but the fundamental engineering work taking known science and things about physiology and mechanics and whatever was coalesced in a master's thesis to prove the concept, an engineering master's thesis.

I think our point about educating properly professional talent in engineering is critical to this concept.

Mr. **Walgren**. Mr. Dymally?

Mr. **Dymally**. I suggest that we forward that information from Dr. Kersten to the Space Subcommittee because they are presently discussing this issue.

Just one question to Dr. Kersten. We know that tuition has increased and the opportunities for a higher education are somewhat limited because of the limited amount of fellowships. A number of students are going into the community colleges.

Do you think NSF ought to be thinking about sending grants to community colleges that are preparing students for university entrance?

Dr. **Kersten**. For scholarship grants at the community college?

Mr. **Dymally**. To community colleges for science majors, math, engineering majors.

Dr. **Kersten**. In some way maybe, but I would suggest that a broad-scale approach within the community college structure may not be warranted because in those early years most community college have open admissions and so on, they are sampling courses here and there, doing the general education work preparatory for specific study.

Until that self-selection process has been made, perhaps not. After it has been made, yes.

Mr. **Dymally**. Thank you, Mr. Chairman.

Mr. **Walgren**. Well, let me thank you on behalf of the committee, Dr. Kersten. We certainly appreciate that. That newspaper article we will make part of the record, and we appreciate your contribution.

[The information follows:]

[The Orlando Sentinel, Sunday, Feb. 5, 1984]

MASTER'S DEGREE RESEARCH LAID FOUNDATION FOR SPACEWALK WITH BACKPACKS

(By Charlie Jean)

Houston.—Development of the 330-pound, $45 million backpacks that will power astronauts Bruce McCandless and Robert Stewart to and from the shuttle this week started with a young engineer's research for a master's degree in 1961.

Charles Whitsett Jr. was an officer at the Air Force Institute of Technology at Wright-Patterson Air Force Base in Ohio when he decided to develop a way for astronauts to fly in space without lifelines.

"It looked like it could be done," said Whitsett, whose early model was tested inside Skylab during its three missions in 1973 and 1974. "We just had to figure out how."

He left the Air Force in 1977 to work on the backpack project for NASA.

The final version to be tested Tuesday and Thursday by McCandless and Stewart is worn on the astronauts' backs over their spacesuits.

Each unit has 24 nitrogen thrusters that draw from two propellant tanks that contain enough fuel for up to six hours of operation.

Special flight service stations installed in the shuttle's cargo bay are used to refuel the tanks.

If all the thrusters were fired at once for four minutes, an astronaut could zip about at 45 mph. However, McCandless and Stewart plan to move about at a cautious 2 mph.

On each of the two arms on the units are levers that control the thusters.

The astronauts use their right hands to operate the controls for spinning or tumbling. With their left hands, they control horizontal, vertical movement.

A minicomputer and gyroscope that automatically fire the thrusters enable the astonauts to remain stationary and use their hands for work.

The backpacks were manufactured by Martin Marietta's aerospace division in Denver.

"If you needed to make another it would cost $8 million–$10 million," a company spokesman said. "Those are the only two in existence.

"It is a totally redundant system in that all operating systems are duplicated for safety in the event of a malfunction," the spokesman said.

Martin Marietta also has a third unit on hand that could be upgraded to flight status at a cost far below the cost of a new backpack, they say.

The company also built a simulator at its Denver plant for astronaut rehearsals. Whitsett himself spent more than 100 hours flying in the simulator.

The 47-year-old engineer is confident the backpacks will work properly.

"It's very easy to fly," he said. "Astronauts can learn to fly it in five minutes. Some of the Skylab astronauts said it became as natural as walking. They didn't have to think about how to get to where they wanted to go—it just became automatic."

Mr. WALGREN. The last witness today is Dr. Robert Barker, the vice president of research and advanced studies at Cornell University. Dr. Barker, welcome to the committee. Your written statement, Dr. Barker, will be made part of the record, and please proceed.

[A biographical sketch of Dr. Barker follows:]

Robert Barker, Ph.D.

Dr. Barker is a biochemist who has been involved in teaching, academic research, and administration for the past thirty years. He has held faculty posts at several universities and is currently Vice President for Research and Advanced Studies at Cornell University. Dr. Barker is responsible for eleven technology centers at the University covering a broad spectrum of science and technology activities. He oversees the Office of Sponsored Programs, the Graduate School, and is responsible for corporate liaison in the area of research.

As an educator, he has been in the Department of Biochemistry at such leading universities as Tennessee, Iowa, Michigan State and Cornell. He has directed six masters students, ten Ph.D. candidates, and seven postdoctoral fellows. Dr. Barker has had an active research program with emphasis in the molecular structure of cell surfaces, and has in progress chemistry and biochemistry projects. He has written extensively and has authored and co-authored twelve chapters and a book and had over sixty technical papers published.

Dr. Barker is Chairman of a group representing the Centers for Advanced Technology which are located on the campuses of seven leading universities in New York State. These Centers are funded by New York State and research-oriented corporations. They conduct advanced research in such areas as micro and super computers, software, telecommunications, optics, and biotechnology.

At Cornell Dr. Barker led the establishment of a university-industry-government partnership to launch a major effort in basic biotechnology research at the University. This institute is the first of its kind in the nation and involves a total initial investment of over $12 million. He is a member of the American Chemical Society, American Society of Biological Chemists, American Association for the Advancement of Science, and the New York Academy of Science. He has served as a consultant to NIH, NAS-NRC, the Veterans Administration, the Los Alamos National Laboratory, and many other research-oriented institutions and universities.

A native of England, Dr. Barker was educated at the University of British Columbia (B.A., M.A.) and the University of California at Berkeley (Ph.D. in biochemistry). He has done postdoctoral work at Washington University and the National Institutes of Health.

STATEMENT OF ROBERT BARKER, VICE PRESIDENT, RESEARCH AND ADVANCED STUDIES, CORNELL UNIVERSITY

Dr. **Barker**. Thank you. I would first like to emphasize and concur in some of the things that were said by Dr. Wyatt. I am very pleased with the progress that he was reporting on in considering matters related to the computer sciences and supercomputers. I realize I am here to talk about biotechnology, but I would like to support that and also to stress the need for some consideration of what the best policy would be within NSF with regard to the information sciences, because they do happen to cut across essentially all disciplines, including biotechnology.

And, finally, and this is going to come up in what I am going to say, to the need for the management of NSF to be responsive to the changing needs of the science and engineering community.

I would like to start by saying that I am representing on my own behalf and on the behalf of many of my colleagues the enthusiasm they have for the high priority that has been given to the NSF appropriation this year, and I would like to point out that that has an important outcome which may not have been mentioned before, and that is that it delivers a signal to the country at large that the Federal Government values the activities of the National Science Foundation and it values basic research, basic engineering activities.

In the last few years there has been a really strange message delivered to students who are thinking of what career to choose, and as a person who advises students, it is often that students come in to ask advice about what career to select, and you should recognize they do that when they are sophomores and juniors in universities. They don't do it when they are in graduate school; they have already decided.

The condition of the research environment has been such that most people who are in it and who can really advise students with regard to careers in it have had to be extremely cautious about advising talented students to pursue that kind of activity. I think that messages are as important as money in this regard, and the message that came out with the Presidential Young Investigator Awards does distill back to the undergraduate. It says that there are opportunities there and exciting things to be done if you decide to pursue science.

Biotechnology. I, during the last 2 years before I got into my present job, had the responsibility for developing a biotechnology program at Cornell University, and I believe that despite the fact that Cornell University has a dozen centers and institutes, all of which are of a disciplinary nature, the biotechnology program is the most broadly interdisciplinary one. That is an important point.

At the moment, I believe there are at least two or three dozen biotechnology centers and institutes that have been formed in the United States and as far as I am aware, none of them has been supported by NSF. I think I should caveat a little on that rather blunt statement. You may interpret it incorrectly.

Biotechnology is the business I think, in terms of basic support, of the National Institutes of Health, of the U.S. Department of Agriculture, and NSF, and it is, therefore, not clear that NSF should have taken on full responsibility to initiate those kinds of things.

But in exploring with them the possible support of biotechnology, I think that one of their management difficulties becomes apparent, and that is that they have an organizational structure in which, when it is functioning at its very best, the program directors have a lot of autonomy and really do behave very creatively in terms of their responsibilities to support science not only in the discipline but in the fringes of that discipline. I guess when it is functioning at its worst, the opposite happens, that the program directors tend to see their responsibilities rather narrowly.

And that brings me to a conclusion that there are two ways to try to deal with new opportunities within a structure like that. One is to create another program whose business it is to look after engineering. But I think the kind of thing which has happened on many campuses in terms of trying to organize interdisciplinary activities may work within NSF; that a system has developed in which the interdisciplinary program has a certain amount of resources for allocation and distribution for which people can compete, and the disciplines that it draws from also have resources and the thing only moves and the goals of people who are participating in those programs are only met when the two resources—and there are many more than two in something like biotechnology—but when the interdisciplinary resources can work with the disciplinary ones on some basis of shared support of what is to be done. Science grows along disciplinary lines, and I don't want anything I say to be interpreted that we should back off from disciplines, because those are the things which feed the opportunities for cross-disciplinary innovation. But I point out that much of the innovations you would like to see coming from this do come from the cross and interdisciplinary kind of mode. And, therefore, the Foundation has to be alert to that and have a management system which would address it.

I was very pleased to hear that there are studies beginning—it will be recommended that studies be undertaken to look into that aspect. Biotechnology is the responsibility of several agencies, and it is a tremendously interdisciplinary activity.

I think one other aspect of it, which you have a clear interest in, is that it has been the focus, in most of the programs that have been started, for university-industry collaboration and in some cases for university, industry, government, including State, as well as Federal Government, collaboration. State governments have gotten into support of biotechnology further than has the Federal Government in the interdisciplinary program approach.

There is a role for NSF to play that is interdisciplinary. They have put out a brochure. I draw attention to the fact that basically it identifies the 32 different programs, but it is not clear that there is a method there to deal with something which was trying to create a programmatic type of activity.

The NSF I think has probably got areas of responsibility that will not necessarily be picked up by the NIH or the USDA. Those have to do with impacts of biotechnology in chemical engineering, in chemical manufacture, to some degree in the pharmaceutical industry, even though that may seem to be principally NIH's business.

NSF has a super record of supporting some kinds of interdisciplinary functions and the materials science labs are an example which I think have worked extremely well. However, that support comes out of a program that has not a defined responsibility, and it is harder for me to see how that would fit within biotechnology. Next year it will be something other than biotechnology, and, therefore, I think the management system has to be able to be on its toes with regard to new opportunities.

Thank you very much.

[The prepared statement of Dr. Barker follows:]

Subcommittee on Science, Research and Technology
Committee on Science and Technology
U.S. House of Representatives

Testimony by: Robert Barker
Vice President for Research
and Advanced Studies
Cornell University
Ithaca, NY 14853
607-256-7256

February 29, 1984

Congressman Walgren, members of the committee, I am pleased to have this opportunity to comment on the proposed FY 1985 NSF authorization. I represent a University that draws a substantial part of its sponsored research funding from NSF (well over $30 million in 1983), most of it in support of the physical sciences and engineering (physics, astronomy, materials science, geology, submicron structure). My colleagues and I wish to express our strong support for the initiative shown to increase NSF funds for basic research in the sciences and engineering, including monies for training and especially the assistance given to young scientists and engineers through the Presidential Young Investigator Awards.

It is axiomatic, although we have not always paid attention to the axiom, that investment in the front-end of processes presents the most powerful opportunity to influence the process. If you want to engineer a plant or an animal, you must do it when it is a single cell. If you want to steer economic development based on high-technology, you must invest in basic research and the young people who hold its future.

In the last decade federal policies and their modes of implementation have delivered many strange messages about our commitments to research. Until recently, funding for research programs has continued at reasonable absolute levels, but with declining purchasing power. Training commitments have declined steadily.

The message to young scientists who make career decisions as college sophomores and juniors is that research careers in science are not valued and represent an unduly high risk. For engineers, as you know, the problem lies in the marketplace. It is clear to me that NSF actions of the last two years reflect an awareness of these problems, especially in the engineering disciplines.

My main reason for appearing today is to talk about interdisciplinary programs with some focus on biotechnology. Cornell has more than a dozen interdisciplinary programs, ranging from the National Astronomy and Ionosphere Center (NSF funded) to the Cornell Institute for Social and Economic Research (not externally funded). The most recent is a Biotechnology Institute, established this fall, and a Theory and Simulation Science and Engineering Center, which is before the faculty for approval. These centers exist, in almost every case, because the world does not present its problems along disciplinary lines. Centers are devices to facilitate inter- and multidisciplinary approaches to real problems. Often they provide resources to their membership that could not otherwise be provided. Center members live in two worlds -- a disciplinary world dealing with special research interests and instruction and a shared world of the research center.

As science has developed, a number of disciplines have become entrenched. In fact, they must continue to exist and be supported because they are fundamentally important. Scientific progress, however, is also made when disciplines can be combined in creative ways. Biotechnology is such a case. It is essential that the universities that do biotechnology research and the agencies that do and should support them function in recognition of the inter- and multidisciplinary nature of this field. It includes molecular genetics, bioreactor design, computer modeling of biological receptors, and monoclonal antibody production. In the slightly longer term it will include large scale scientific computing (supercomputing) as will other biolcgical disciplines supported by NSF.* To ensure the best research and most rapid utilization of research findings it will be essential to create environments that favor cross-disciplinary research and training.

NSF has announced a biotechnology initiative in its bulletin "Biotechnology and NSF: Opportunities for Support of Biotechnology Research and Related Activities, October 12, 1983." Quite properly this bulletin draws attention to the fact that NSF provides support through many programs. In fact the bulletin lists 32 programs that can provide support, and applicants are invited to mark their proposals "Biotechnology Proposal" when applying to these programs. The Office of Interdisciplinary Research "will assist in arranging joint-program consideration, as appropriate." This organizational structure probably will present a major problem to the responsible coordinator.

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*It is reassuring to see NSF addressing needs in this area -- again, it is one of the interdisciplinary needs that must be managed to serve a common good

It appears that the Biotechnology Program Coordinator will have to deal principally with program officers who will be protective of the established areas they represent. Nevertheless, some structure of this joint-program type must be used since new and important interdisciplinary needs will probably arise and it is unlikely, even undesirable, to create a new, separate program for each. The university model, wherein some control of resources is given to the interdisciplinary program (center), might be appropriate. (Just enough to ensure that the disciplinary elements will participate in the program.) In the NSF biotechnology program, this control could come from resources assigned through the Office of Interdisciplinary Research or from giving the Biotechnology Coordinator sign-off control. Having the appropriate Directorate heads made responsible for program success and giving the Coordinator easy access to them would also help ensure that the truly inter- or multi-disciplinary programs that are biotechnology will be given fair consideration.

In closing, I want to make clear that NSF has administered many very successful interdisciplinary programs, generally by creating a new program to meet the need. An example -- the 14 Materials Research Laboratories operated through the Materials Research Program in the Directorate for Mathematical and Physical Sciences. However, not every new interdisciplinary program should result in a new administrative unit. Despite the territorial anxiety that it might generate in-house, a "matrix management" system that puts some resources in the interstices when a new fusion is desired is essential.

Thank you.

Mr. **Walgren**. Thank you very much, Dr. Barker.

As I understand it, the strict application of the peer review process in an interdisciplinary area is a little difficult.

Dr. **Barker**. It can be extremely difficult depending on how many areas come together. The best sort of situation is to have a group of peers who have to interact themselves, examine things if the peer review process is to be used. That is that you would have both peer review for elements proposal and perhaps an interdisciplinary look at it by a group who work together and become aware of the interdisciplinary nature of things.

That has happened in our own institution where the program we set up has funding from the State and from some corporations, and it is used on campus to run a little NSF basically. But the thrust of the applications that we will react positively to has to be interdisciplinary; it has to bridge some of the disciplines we see needing to be bridged.

It seems to me that is not impossible for a national agency to do the same thing. It doesn't avoid peer review. It structures it so it is appropriate to what you are trying to accomplish.

Mr. **Walgren**. NSF's approach has been to have a coordinator for interdisciplinary biotechnology programs?

Dr. **Barker**. That is correct, and I believe the named person is a very good person.

Mr. **Walgren**. And you suggest that his hand might be strengthened by giving him some ability to allocate funds?

Dr. **Barker**. Yes. I don't want to get in the mode of micromanagement recommendations with regard to NSF, but I think that I have seen enough situations in which on the campus we are trying to do the same kind of thing, and I am not speaking just of biotechnology, in which we have to accomplish it—draw resources both from established disciplines and from the center. Things work much better when they each have resources that can be allocated rather than when one has to convince the other that its resources should be allocated to the program.

Mr. **Walgren**. Presently NSF is in a position where that coordinator doesn't have that kind of——

Dr. **Barker**. That is not clear from what is stated here. I haven't had an opportunity to find out whether they will or will not. At least as it is presented, it doesn't appear that they have been inviting really interdisciplinary things specifically or indicating a source of funding from them although it is quite possible they will respond in that way if the right kind of application comes in.

Mr. **Walgren**. Why do you think it is that industry and universities have gotten more involved in biotechnology than they have together in other areas?

Dr. **Barker**. I think the fact is that genetic engineering, which is the sort of catch phrase for the new elements that go into biotechnology, was carried out mainly in university laboratories mainly with funding from the NIH and NSF, principally NIH I think in terms of volume of money, and was driven to understand how biotechnology works, how it uses the information it has and delivers that information.

The corporate world was not aware of what the implications were of a whole series of very basic kinds of studies and, therefore, when they did become aware of it, the recognition was they did not have people in their own R&D programs who could respond to that.

In many cases—I have talked now with representatives from about 40 corporations, and every group have told me they don't understand the language even and that that is a problem. There are remarkable exceptions to that; there are corporations with great strength in the area.

So the problem was how to go about discovering whether this new biotechnology had any relevance to the corporations, and the way to do that is to try to make a linkage with a university. I must say that the programs that I know about have mostly been initiated by university faculty members, and I think that is very heartening because it indicates the fact that basic scientists are really quite interested in seeing what they do translate into development, economic as well as other.

So I think the situation was that the work lay mostly in the universities. That is changing. There have been some 160 or more new corporations formed that deal in biotechnology and so at least those corporations have all got some element of it in hand. Many of the larger corporations have started new programs in that area.

I would like to come back to—at the beginning I indicated it is very important to send out signals about what are useful and important and exciting things for young people to do. The enrollment of graduate students in the basic biomedical sciences, the ones which feed biotechnology, has decreased by 20 percent over the last 6 years. That is the new enrollments, not the total.

During the same time, amount of time, the total enrollment has gone up. The number of Ph.D's granted, which is the step that is really necessary for someone to work creatively in this field, has stayed pretty much constant. It is not clear whether the decreased enrollment of students is beginning to result in a decrease of Ph.D's granted, but it is likely that there will be some.

That is happening at a time in which the industries involved in this area are saying that there is a reasonably substantial demand coming up for people trained in these areas. As a matter of fact, if you allow some extrapolations, which are reasonable, about 1990 the lines will close; that is, of Ph.D's available to enter the job market and Ph.D's being produced.

I think that for those of us who have been in the area, the problem has been not that there aren't exciting and important things to do but that the prospect of getting a good shot at doing them has been declining.

As I said, I think signals are very important in this regard.

Mr. **Walgren.** How do you measure our capabilities against that of other countries? Is more happening abroad?

Mr. **Barker.** No, it isn't. I think that if you look at the Nobel Prize roster you will find that the research areas from which biotechnology sprang drew a lot of the prizes. A very large proportion of the awardees are in this country. Europe also has significant strengths. Japan, on the other hand, has not built so much in this area, it has built more on applications. The biotechnology program at Cornell is designed to bring corporate scientists to the campus to learn what is going on.

In other words, we are trying to get the corporations to start a sabbatical program for their scientists to bring them back and get them caught up on some of these new things. I examined how many corporate scientists there were on the campus working in this area. There were none from the United States, but there were several from Japan.

Mr. **Walgren**. Thank you very much.

Mr. Brown?

Mr. **Brown**. Mr. Chairman, first of all, I think this question of interdisciplinary programs and how they are handled at NSF is important, and I appreciate Dr. Barker's bringing it to our attention.

I wonder if we could get the staff to request for the subcommittee the material describing the biotechnology program and possibly any other programs of an interdisciplinary nature in NSF so the committee could have that material in its files, and I would personally like to look at some of it.

Also, Dr. Barker, could you provide a description of your institute at Cornell as an example of, of course, one of the better institutes no doubt?

Dr. **Barker**. Yes, I could. Thank you. That is yet to be proven, but thank you anyway.

[The requested material is in the subcommittee files.]

Mr. **Brown**. I was a little surprised that you mentioned that there were a dozen or more such institutes springing up around the country, and I would like to get more information——

Dr. **Barker**. I happen to have here a book listing about 90 different university/industry collaborations which are going on. For reasons other than appearing here I have a person who has been trying to collect that information. There are some OTA publications which deal with it also.

[The booklet, "Examples of University-Industry—(Government) Collaborations," is available in the subcommittee files.]

Mr. **Brown**. Yes, OTA has published recently an extensive survey of this and unfortunately I haven't read all the details of it yet, just the summary. Perhaps some of my questions would be answered if I read that. But I would appreciate that additional information.

In dealing on an interdisciplinary basis with problems of this sort, you will bring in scientists from several disciplinary fields, obviously. Does that ever include per chance outside of the biological field, the physical scientists and social scientists?

Dr. **Barker**. Yes. If I speak of the biotechnology program at our institution, and I don't think it is unique in this particular regard, it includes faculty members from engineering, arts and sciences, which are chemistry and physics, agriculture and veterinary medicine. Those are the four main colleges, but there is one person from Human Ecology, and there is a Division of Nutrition and a Division of Biological Sciences. Altogether when the program reaches maturity, I would expect it will have about 70 or so faculty members involved and a very large number of students, and they will come from as far apart as applied physics and physiology.

Mr. **Brown**. You spoke in commendatory terms of the Presidential Young Investigator Awards, and as I recall the situation, social scientists are not eligible to receive these awards, and I have had some question about that. I wonder if you could comment on whether it might be desirable to include a broader range, including the social scientists as eligibles for these awards?

Dr. **Barker**. My answer would be yes. Cornell did rather well in regard to those awards and it was interesting that 10 of them were in engineering and one was in chemistry to an individual who is involved in our material science program, and when you look nationally, there were a relatively small number that came outside of those disciplines which were either in engineering or closely related to it.

I am in favor of that emphasis, though, because I think it is important to deliver a message that careers in the research related to engineering are important, significant, and that there is this kind of support for them. But I would hope as the program develops that it would become accessible in real terms to people in other disciplines, that it would not—I am in favor, in other words, of the front-end loading, if you will, but I think in addition we probably have the same problem in the social sciences, and I am not a social scientist, but it is my impression from talking with the people on our campus, of which I have done a good deal in the last few months, that social sciences were just getting to the point where they could really deliver some things when the support for them diminished.

In other words, I think there is every reason to believe that the social sciences and economics could play a strong role now that there are information systems in place which they can use and provide really very useful outcomes, which are probably, when well done, as important as the technological developments.

Mr. **Brown**. Well, I don't want to rank far afield, but I have a sneaking suspicion that when we reexamine the farm bill next year, instead of looking as strongly as we have at the problems of agricultural productivity from a strictly physical standpoint, that is how do we improve the strains of plants and animals and increase the productivity per input unit of the farm, we are also going to look at some of the social science aspects including marketing, economics and other social sciences in terms of how we can restore a healthy agriculture to this country. Cornell probably will be interested in that I suspect.

The initiative, the very praiseworthy initiative of the Foundation to encourage more centers for fundamental engineering research seems to me to be a subset of this encouragement of additional interdisciplinary research, because I can't conceive of a fundamental engineering research center as not involving at least a number of engineering disciplines and probably disciplines outside of the engineering field.

Dr. **Barker**. I agree with that. I think the—I mentioned in material science laboratories, if you look at who people such laboratories, you find it is chemists, physicists, and engineers, and engineers from a variety of disciplines, so that is a very good and clearly a successful working marriage. Those centers have been in existence for 20 years or so.

Mr. **Brown**. Well, I very much appreciate your testimony. It helps to clarify this picture for us.

Dr. **Barker**. Thank you.

Mr. **Walgren**. Thank you very much, Dr. Barker.

I am sorry—let me recognize counsel for the minority, Ms. Bach.

Ms. **Bach**. Thank you, Mr. Chairman.

I just want to ask a quick question. You commented on the collaboration between university and industry, but could you comment on the maturity of the biotechnology industry at present. We have seen a proposal from the National Bureau of Standards for involvement in biotechnology specifically to establish standards for commercial use. And I am wondering, in your opinion, how far along is industry in terms of requirements for standardizations of either processes or whether it be growth media or various techniques that are required for genetic engineering. Would you have a feel for how mature that industry is?

Dr. **Barker**. It is more mature than you might think it should be on the basis that most of the firms who have started up and declared themselves to be in it are only about 3 or 4 years old. I happen to have done a study last year in connection with another activity here at the National Academy of the biotechnology industries trying to find out their needs for people and areas in which they needed them. Most of them are quite new.

But it seems to me that what is being said by the National Bureau is that one should be ready—I hadn't thought about the issue before—as I think about it, it seems to me they must have already activities that relate to this. For example, if they are concerned about the standards for the purity of things like insulin, then they must have standards for purity, and it may be that those which are bioengineered need a revised standard because they come—insulin up until now has been coming from pigs.

Now it will be coming from bacterium and the residual materials, if there are any—there hopefully would be none, but as you know, it is very difficult to reach the level of zero on anything, the residual materials would be from a different source and might have different outcomes, and there may need to be different standards established for that.

So as far as I know, there are relatively few products on the market, but there are a lot at least being reported as going to come on the market, and it would seem to me we have a couple of problems with that. One is the purity question and who is going to be the arbiter of whether things are pure enough, and the other is for those things which we might put into the environment, are we satisfied that we have the right standards for regulating that?

I am not suggesting a new set of regulations, but it does seem to me that EPA would have some interest, and I believe it does in that area.

Mr. **Walgren**. Thank you very much.

That concludes the series of hearings.

[Whereupon, at 10:55 a.m., the subcommittee was adjourned subject to the call of the Chair.]

1985 NATIONAL SCIENCE FOUNDATION AUTHORIZATION

WEDNESDAY, MARCH 21, 1984

House of Representatives,
Committee on Science and Technology,
Washington, D.C.

The committee met, pursuant to notice, at 9:35 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

Present: Representatives Fuqua, Brown, Walgren, Walker, Sensenbrenner, Gregg, McGrath, Skeen, Schneider, Lowery, MacKay, Bateman, Boehlert, and McCandless.

Staff present: Harold P. Hanson, executive director, and David S. Jeffery, minority staff director.

Mr. **Fuqua**. The committee will be in order.

This is a special hearing for 1 day prior to the committee's markup of the fiscal year 1985 authorization for the National Science Foundation. Last week the committee's Subcommittee on Science, Research and Technology agreed to an amendment to the authorization that would amend the NSF Organic Act in order to reflect an emphasis on engineering in the appropriate places in the Foundation's basic charter.

The purpose of the hearing is to provide the committee members with the views of representatives of the scientific and engineering community, including the National Science Foundation, the National Academy of Sciences, the National Society of Professional Engineers, the American Association for the Advancement of Science, the Association of American Universities, and other groups.

It's my understanding that the National Academy of Engineering and the National Science Board are submitting views in correspondence to the committee, and these will be included in the hearing record.

Other interested parties are invited to express their views in written statements to the committee, and these statement also will be included in the printed hearing record.

At this time I would like to recognize Mr. Walgren, the chairman of the Subcommittee on Science, Research and Technology for any comments that he chooses.

Mr. **Walgren**. Thank you very much, Mr. Chairman.

I particularly appreciate the full committee being able to change its schedule to make room for having a hearing today and inviting the witnesses that came on very short notice. I think we all owe them a particularly special debt for going out of their way to address this issue in a formal fashion.

As you know, last week, as part of the subcommittee's markup of the authorization for fiscal year 1985 of the National Science Foundation, there was a very broad and general consensus in the subcommittee in support of an amendment offered by Mr. Skeen and Mr. Brown to amend the Organic Act in order to increase the emphasis on fundamental engineering research.

This was a subject that had been tangentially discussed in the hearings and raised in a number of different ways in the history of our committee's involvement with the National Science Foundation, raised in other legislation that has been introduced by Mr. Brown and cosponsored by others, that try to respond to the need to serve our society in the best possible way in our preparedness and capacities related to engineering, which is so fundamental to everything.

It is true that we did not have direct testimony in a very focused way on this version of the amendment. This amendment does not, as some former legislation had, change the name of the Foundation to broaden it to directly include engineering, but it does interlace throughout the Organic Act a parallel reference to engineering, and in that sense does substantially direct the attention of the organization, the National Science Foundation, to that mission, which the Science Foundation has in fairness really tried to be sensitive to and has at least addressed.

It seems to me that there are fundamental questions here. No. 1, we should not be amending the Organic Act lightly. There are other needs that will certainly have to be addressed, and it is something where we want to have a very careful record in support of changes we make in that structure of the law. So I think it's important that we have that hearing in this sense.

I don't know how to weigh the questions of whether or not this is the best way to get at engineering. Others have suggested a technology foundation, and I do think that the emphasis of the Science Foundation on pure science as opposed to the general mission of technology is something that we have to consider, whether or not there be a better way to do that.

And, second, I'm struck by the fact that just from first blush the National Science Foundation does have a role in a very focused way on science in a narrow sense, and that as we broaden the mandate, if we do not substantially increase the funds, the depth of the water gets more shallow.

And I do feel we all are concerned that we maintain the strength of the science function in a pure sense, as is clearly justified by the modern world and a Government and a society such as ours, which is not to say that engineering should be excluded, but that we have to figure out, certainly, what is the best way to address it.

So I do appreciate the chairman of the full committee scheduling this hearing to give us a chance to reflect on those and other considerations, and I want to express my appreciation to the witnesses for making themselves available for this process.

Thank you, Mr. Chairman.

Mr. **FUQUA**. Thank you, Mr. Walgren.

Mr. Skeen, did you——

Mr. Skeen. Thank you, Mr. Chairman. I'd like to thank you for having this special hearing this morning, and I also would like to thank my subcommittee chairman because I know he's had a great concern over this and felt that there had not been enough airing of the pros and cons. And I would in no way want to push something that had not had a good hearing, and I appreciate his concern.

This is not the first time that we've dealt with this question in this Congress or in previous Congresses. It's been an ongoing concern of those who are interested in fundamental engineering research. It's also a concern amongst scientists, whether they're engineering scientists or pure scientists—and, by the way, the disciplines are such these days and the lines that are drawn, or used to be drawn traditionally, have rather blurred because technology is moving so fast that I think that almost every engineer and every scientist has to be guilty of trespassing in one another's domain, or what used to be considered domain in the past.

This amendment addresses the Organic Act, as Mr. Walgren has said. I do not see it as a threat to any kind of funding for these disciplines. As a matter of fact, probably with the inclusion of the wording that is in this amendment it might accrue to even more flexibility in funding and provide more funding for so-called pure science or pure fundamental engineering research.

For far too long, I think that we have tried to build the ivory towers of these various disciplines without understanding that they all work together; that an engineer today is not like an engineer some 35, 40 years ago, nor is a scientist today the same kind of discipline or the same kind of person, even those who have practiced and stayed within the so-called pure realm of their expertise.

Now, I know that there's an awful lot of egoism, if I may be crass enough to say that word, in connection with the sciences and the disciplines and the engineers, and so forth. Everybody has a little prestige edge that they like to operate with.

But I think that in technology today, it's time we face the fact that it moves very quickly, very responsively, and so on.

So I'm glad we're having these hearings, further hearings, even though this amendment was passed unanimously. It was an effort that was begun by Mr. Brown and myself to address this ongoing problem, which has been with us in both of the Congresses that I have served in. I do not see it as any kind of threat, and appreciate the fact that we're going to give it further hearing. And I would like to hear, because we made a very strong effort to find out where the opposition was and to compromise, and this amendment represents the best thinking of many people who had input.

And so, once again, I want to thank the witnesses who appeared here again today. It's a little bit redundant maybe, but we appreciate the fact that this is the kind of forum that we hammer these things out. We're not railroading anything.

And I appreciate the time very much, Mr. Chairman, and the reconsideration on this particular amendment.

Mr. Fuqua. Thank you, Mr. Skeen.

Our first panel—and I understand Dr. Press, because of schedule conflicts, will have to depart after his testimony and maybe after a few questions, but we will begin with Dr. Frank Press, and followed by some strange person who I see sitting there, Tom Ratchford, former distinguished staff member of this committee, and also Dr. Rosenzweig, who is president of the American Association of Universities.

So, Dr. Press, we're pleased to have you once again before our committee, and we would be pleased to hear from you.

[A biographical sketch of Dr. Press follows:]

October 1983

FRANK PRESS

Frank Press was born in Brooklyn, New York in 1924. He received his undergraduate degree in physics from the City College of New York, and advanced degrees in geophysics from Columbia University in 1946 and 1949, when he joined the Columbia faculty, becoming associate professor in 1952, working in the areas of geophysics and oceanography. In 1955 Dr. Press was appointed professor of geophysics at the California Institute of Technology, and two years later became director of its Seismological Laboratory. He was named in 1965 as the head of the then Department of Geology and Geophysics at the Massachusetts Institute of Technology (MIT), which, under his leadership, expanded into planetary sciences, oceanography, interdisciplinary studies, and the joint program with the Woods Hole Oceanographic Institution, and was renamed the Department of Earth and Planetary Sciences. In 1977 he was appointed by President Carter as the President's Science Advisor and Director of the Office of Science and Technology Policy. In January, 1981, he returned to MIT where he was appointed Institute Professor, a title MIT reserves for scholars of special distinction. Dr. Press returned to Washington in July 1981 as the 19th President of the National Academy of Sciences, elected by its members to a six-year term.

Dr. Press is recognized internationally for his pioneering contributions in geophysics, oceanography, lunar and planetary sciences, and natural resource exploration, but his primary scientific activities have been in seismology and the study of the earth's deep interior. Recognizing the importance of long-period surface waves in studying the earth's structure, he developed the theory for these waves and the instrumentation to record them. Today the analyses of seismic surface waves and free oscillations are among the most powerful techniques for studying the structure and properties of the earth's crust and deep interior. Dr. Press also saw the need to develop techniques for geophysical studies of the moon and planets, using landed observatories. Author of 160 scientific papers, he is also the co-author of the textbook Earth, widely used in courses in both American and foreign universities.

Dr. Press has been a leader in major national and international projects. He helped organize and gave impetus to the International Geophysical Year, the first coordinated worldwide attempt to measure and map various geophysical phenomena, a decade-long effort that involved international explorations of Antarctica and the oceans. Mt. Press in Antarctica is named for him. Dr. Press provided leadership in research efforts on earthquake prediction in the United States, and in international cooperation with Japan, the USSR, and the People's Republic of China.

As NAS President, Dr. Press will continue a long career of public service, in addition to his distinguished scientific work. He served on the President's Science Advisory Committee during the Kennedy Administration and on the Baker and Ramo Presidential Advisory Committee during the Ford Administration. He was appointed by President Nixon to the National Science Board, which is the policy-making body of the National Science Foundation, and he also served on the Lunar and Planetary Missions Board of the National Aeronautics and Space Administration. Dr. Press participated in the bilateral science agreement negotiations with the Soviet Union, and was a member of the U.S. delegation to the nuclear test ban negotiations in Geneva and Moscow.

Major initiatives of his Washington service as OSTP Director and Science Advisor during the Carter Administration included increasing the Federal commitment to the support of basic research; the introduction of new measures to spur industrial innovation; joint research ventures involving industry, the university, and the government; and regulatory reform, particularly in improving the scientific basis of proposed regulations. Dr. Press was largely responsible for the U.S.-China scientific cooperation agreements in 1979.

Dr. Press is a member of several professional organizations, and is a former President of both the Seismological Society of America and the American Geophysical Union. He was elected to the National Academy of Sciences in 1958, the American Academy of Arts and Sciences in 1966, and the American Philosophical Society. In 1981 he was elected as a foreign member of the French Academy of Sciences, and to the Board of Trustees of both the Sloan Foundation and Rockefeller University, as well as to the membership of the Corporation of the Massachusetts Institute of Technology. He is the recipient of numerous honors, among which are the Gold Medal of the Royal Astronomical Society, the Arthur L. Day Medal of the Geological Society, the Bowie Medal of the American Geophysical Union, and in 1982, the Maurice Ewing Medal of the Society of Exploratory Geophysicists. He was awarded the Department of the Interior's Public Service Award in 1971 and NASA's Distinguished Public Service Medal in 1973. In 1982, during the 9th Annual Survey of American Leaders conducted by U.S. News and World Report, he was named the most influential man in science. Dr. Press has received 15 honorary doctoral degrees. His unique distinction lies perhaps in the dual contribution of the impact of his scientific work on the development of modern geophysics and the influence of his personal leadership in national science planning and administration.

Dr. Press is married to the former Billie Kallick of St. Louis. The Presses have two children and one grandchild.

STATEMENT OF DR. FRANK PRESS, PRESIDENT, NATIONAL ACADEMY OF SCIENCES

Dr. PRESS. Thank you, Mr. Chairman.

I appreciate this opportunity to testify on Representative Skeen's proposed amendment to the National Science Foundation Act of 1950. The comments I will make are supported by the Council of the National Academy of Sciences.

The intent of the proposed amendment is to provide for a stronger emphasis on engineering in the Foundation's programs, principally by inserting the words "engineering" and "engineers" in appropriate places in the text.

As the chairman and members of this committee know well, I fully share the concerns which prompted the suggested changes. I have on innumerable occasions outlined current problems in engineering education and research, and I have spoken to the importance of correcting them to help insure our continuing technological strength, both nationally and internationally.

These problems include faculty shortages; inadequate, often outdated instruments and equipment; and insufficient funding for engineering research. And they include inefficient technological transfer; that is, the transfer of new scientific and engineering knowledge into public and commercial sectors, and also the transfer from industry to the universities of industrial knowledge and needs.

My institution has considered those problems from several perspectives, such as the Nation's future strength in international technological competition. And, last month a national research council symposium addressed the condition of the labor market for engineering personnel. We have underway an examination of the education and utilization of engineers and are just launching a major study of engineering disciplines, modeled on our disciplinary surveys in chemistry, physics, astronomy, and other scientific fields.

The upshot is that my institution and I share the concerns underlying the proposed amendment. There are worrisome weaknesses in engineering education and research. Engineering research has in many instances been underfunded. We do have to act. That agreed, there are, in terms of the proposed amendment, several questions before us. What can be effectively done within the existing statutory framework? Are new arrangements needed, and what are their likely effects, pro and con? What processes should be followed for forming new arrangements and for implementing them?

First: What can be effectively done within existing arrangements? I think the administration's proposed 1985 budget answers the question. For example, there is a substantial increase for engineering research in the Foundation's budget, the largest proportionate increase for any of the Foundation's directorates. Further, the Foundation, with the advice of the National Academy of Engineering, has launched an exciting new initiative for engineering research centers. These centers are intended to encourage cross-disciplinary research and to enhance the experience of engineering students in creating technological systems, within the context of social, economic, regulatory, or other constraints.

One can always argue that this is insufficient. But I think it would be difficult to argue, judging by the budget, that there are impediments to raising the scale of worthy engineering initiatives within the Foundation. Indeed, the programs and budget proposed for the Foundation in fiscal year 1985 appear to move substantially toward the goals set out in Representative Skeen's amendment. They do initiate and support fundamental engineering research. And, with the launch of the program for engineering research centers, they do consider the impact of such research upon industrial development.

However, as this committee well knows, it is misleading to cite only the Foundation's budget in analyzing engineering research. Support for engineering is embedded in the budgets of the mission agencies, with individual agencies providing much more support than the $147 million proposed in fiscal year 1985 for engineering research within the Foundation.

The point is that this $147 million should not be simply measured against the $1.4 billion NSF budget. It should, I would suggest, be considered in the context of the approximately $1.8 billion in the fiscal year 1985 budget in academic support for physical science and engineering to be provided by other agencies than the NSF.

The diverse sources of support for engineering within the Federal Government must be recognized. Also, it must be recognized that engineering, after the life sciences, takes the highest proportion of academic R&D expenditures.

Finally, in 1984, an estimated $786 million was provided by the Federal Government for basic research in engineering, most of that coming from agencies other than the Foundation. These comparatives, I emphasize, are not an assertion that engineering funding is sufficient, but only that the Foundation's programs and budgets are not the appropriate measure of whether the engineering research capabilities of universities are being adequately supported by the Federal Government.

Therefore, answering my own question, while there's no argument that engineering education and research must be strengthened, there is little evidence that within the Foundation there are any procedural impediments to doing so. Further, while engineering support is only about 10 percent of the fiscal year NSF budget, it is actually much larger when the budgets of other agencies with engineering programs are factored in.

However, let's assume that the new arrangements of the sort suggested in the proposed revisions are adopted. What are the likely outcomes? A major change, I fear, may be to dilute the fundamental mission for which the Foundation was created—to support basic research in all the sciences. There have been problems, but the excellence of American science testifies, I believe, to the effectiveness of the NSF in carrying out its mission. One needs to remember that, in contrast to engineering, many of the sciences are not related to any agency's mission except the NSF.

Is there any assurance that as engineering research grows within the Foundation that there will be commensurate growth in the overall NSF budget? If not, what impact will competition for funds have on the sciences which depend heavily, if not exclusively, on NSF support, such as mathematics and chemistry? I emphasize again that this is not an argument against increasing the engineering research budget within the NSF; it is an argument for protecting those fields which do not have the multiplicity of potential funding possibilities open to engineering research.

I'm unaware of any detailed consideration of these possible effects in the legislative history of this amendment, or other pending proposals, which could guide an informed debate on the consequences of a fundamental change in the Organic Act of the NSF. That may have occurred, however, but I'm not aware of it. Overall, while the effects of the proposed changes in NSF's statutory authority are conjectural, they are worrisome.

I will say that I am opposed to this proposed change if its motivation is to transfer half of the NSF budget into engineering by legislative fiat rather than by examining the merits of proposed projects. I hope that the engineering groups who support this amendment do not have this as a goal. And I repeat again that while there is only one agency charged explicitly with supporting basic scientific research, there are several, including the Foundation, for which support of engineering is consistent with their missions.

The third question, which I listed at the beginning of my testimony, is the process for consideration and, when necessary, implementing new arrangements. The role of engineering within the Foundation has been discussed extensively, including the deliberations of this committee. These analyses have been useful and illuminating. They should be continued. However, I would urge that for discussions to be even more fruitful, several elements should be considered.

One: The current problems of engineering, which all agree are real and severe, should be considered in the context of the total Federal effort in R&D.

Two: Changes in the NSF should be examined as to operational necessity and likely effects on the fundamental mission of the NSF. Given the very few changes made to date in the 1950 act, can that act not in its present form provide for a larger role of engineering within the Foundation?

In this respect, the modification proposed by Dr. Knapp in his letter to this committee is reasonable if any change in the 1950 act is made and would avoid an unfortunate, symbolic partitioning of the NSF between science and engineering.

Three: The science and engineering communities—academic, industrial, and governmental—should work together in a constructive way to address the problems of engineering. They, of course, are already doing so, but that process needs to be encouraged. By the same token, one must ask whether legislative remedies will be truly effective in promoting this dialog or may instead lead to corrosive frictions. Will legislative approaches divert us from substantive focus on the issues themselves to largely procedural matters?

Concluding: Amendment of the NSF Organic Act is a serious undertaking, whose consequences remain uncertain. Will there be other requests to amend the act? Will we have a discipline-of-the-month series of amendments, leading to the ultimate decay of one of the most successful institutions established by the Federal Government?

It is not clear to me that the changes are necessary. They may even be counterproductive. What is critical is to continue the dialog underway for several years on engineering. That dialog has already produced very substantial results. And, if conducted in a collegial manner and involving all parties, then we may fashion more effective remedies that will benefit not only engineering, but also science, and the Federal role in research and development.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Press follows:]

STATEMENT

by

FRANK PRESS
President
National Academy of Sciences

I appreciate this opportunity to testify on Representative Skeen's proposed amendment to the National Science Foundation Act of 1950. The comments I will make are supported by the Council of the National Academy of Sciences.

The intent of the proposed amendment is to provide for a stronger emphasis on engineering in the Foundation's programs, principally by inserting the words "engineering" and "engineers" in appropriate places in the text. As the Chairman and members of this Committee know well, I fully share the concerns which prompted the suggested changes. I have on innumerable occasions outlined current problems in engineering education and research; and I have spoken to the importance of correcting them to help ensure our continuing technological strength, both nationally and internationally. These problems include faculty shortages; inadequate, often outdated instruments and equipment; and insufficient funding for engineering research. And they include inefficient technological transfer; that is, the transfer of new scientific and engineering knowledge into public and commercial sectors, and also the transfer from industry to the universities of industrial knowledge and needs.

My institution has considered those problems from several perspectives, such as the nation's future strength in international technological competition. And, last month, a National Research Council symposium addressed the condition of the labor market for engineering personnel. We have underway an examination of the education and utilization of engineers and are just launching a major study of engineering disciplines, modelled on our disciplinary surveys in chemistry, physics, astronomy and other scientific fields.

The upshot is that my institution, and I, share the concerns underlying the proposed amendment. There _are_ worrisome weaknesses in engineering education and research. Engineering research _has_ in many instances been underfunded. We _do_ have to act. That agreed, there are, in terms of the proposed amendment, several questions before us. What can be effectively done within the existing statutory framework? Are new arrangements needed, and what are their likely effects, pro and con? What processes should be followed for forming new arrangements, and for implementing them?

First, what can be effectively done within existing arrangements? I think the Administration's proposed FY1985 budget answers the question. For example, there is a substantial increase for engineering research in the Foundation's budget, the largest proportionate increase for any of the Foundation's directorates. Further, the Foundation, with the advice of the National Academy of Engineering, has launched an exciting new initiative for Engineering Research Centers. These Centers are intended to encourage cross-disciplinary research, and to enhance the experience of engineering students in creating technological systems, within the context of social, economic, regulatory, or other constraints.

One can always argue that this is insufficient. But I think it would be difficult to argue, judging by this budget, that there are impediments to raising the scale of worthy engineering initiatives within the Foundation. Indeed, the programs and budget proposed for the Foundation in FY1985 appear to move substantially toward the goals set out in Representative Skeen's amendment. They do initiate and support fundamental engineering research. And, with the launch of the program for Engineering Research Centers, they do consider the impact of such research upon industrial development.

However, as this Committee well knows, it is misleading to cite only the Foundation's budget in analyzing engineering research. Support for engineering is embedded in the budgets of the mission agencies, with individual agencies providing much more support than the $147 million proposed in FY1985 for engineering research within the Foundation. The point is that this $147 million should not be simply measured against the $1.4 billion NSF budget. It should, I would suggest, be considered in the context of the approximately $1.8 billion in the FY1985 budget in academic support for physical science and engineering to be provided by agencies other than NSF.

The diverse sources of support for engineering within the federal government must be recognized. Also, it must be recognized that engineering, after the life sciences, takes the highest proportion of academic R&D expenditures. Finally, in 1984, an estimated $786 million was provided by the federal government for basic research in engineering, most of that coming from agencies other than the Foundation. These comparatives, I emphasize, are not an assertion that engineering funding is sufficient, but only that the Foundation's programs and budgets are not the appropriate measure of whether the engineering research capabilities of universities are being adequately supported by the federal government.

Therefore, answering my own question, while there is no argument that engineering education and research must be strengthened, there is little evidence that within the Foundation there are any procedural impediments to doing so. Further, while engineering support is only about 10 percent of the FY1985 NSF budget, it actually is much larger when the budgets of other agencies with engineering research programs are factored in.

However, let's assume that the new arrangements of the sort suggested in the proposed revisions are adopted. What are the likely outcomes? A major change, I fear, may be to dilute the fundamental mission for which the Foundation was created -- to support basic research in all the sciences. There have been problems, but the excellence of American science testifies, I believe, to the effectiveness of the NSF in carrying out its mission. One needs to remember that in contrast to engineering, many of the sciences depend on the NSF for the predominent fraction of their support. Is there any assurance that as engineering research grows within the Foundation, that there will be commensurate growth in its budget? If not, what impact will competition for funds have on the sciences which depend heavily on NSF support, such as mathematics and chemistry? I emphasize again that this is not an argument against increasing the engineering research budget within NSF; it is an argument for protecting those fields which do not have the multiplicity of potential funding possibilities open to engineering research.

I am unaware of any detailed consideration of these possible effects in the legislative history of this amendment, or other pending proposals, which could guide an informed debate on the consequences of a fundamental change in the organic act of the NSF. Overall, while the effects of the proposed changes in NSF's statutory authority are conjectural, they are worrisome.

I will say that I am opposed to this proposed change if its motivation is to transfer half of the NSF budget into engineering by legislative fiat rather by examining the merits of proposed projects. I hope that the engineering groups who support this amendment do not have this as a goal. And I repeat again that while there is only one agency charged explicitly with supporting basic scientific research, there are several, including the Foundation, which support engineering.

The third question, which I listed at the beginning of my testimony, is the process for considering, and when necessary, implementing new arrangements. The role of engineering within the Foundation has been discussed extensively, including deliberations by this Committee. These analyses have been useful and illuminating. They should be continued. However, I would urge that for discussions to be even more fruitful, several elements should be considered.

One, the current problems of engineering, which all agree are real and severe, should be considered in the context of the total federal effort in R&D.

Two, changes in the NSF should be examined as to the operational necessity and likely effects on the fundamental NSF mission. Given the very few changes made to date in the 1950 Act, can that Act not in its present form provide for a larger role of engineering within the Foundation?

Three, the science and engineering communities -- academic, industrial, and governmental -- should work together in a constructive way to address the problems of engineering. They, of course, are already doing so, but that process needs to be encouraged. By the same token, one must ask whether legislative remedies will be truly effective in promoting this dialogue or may instead lead to corrosive frictions? Will legislative approaches divert us from substantive focus on the issues themselves to largely procedural matters?

Concluding, amendment of the NSF organic act is a serious undertaking, whose consequences remain uncertain. Will there be other requests to amend the Act? Will we have a "discipline of the month" series of amendments, leading to the ultimate decay of one of the most successful institutions established by the federal government?

It is not clear to me that the changes are necessary. They may even be counterproductive. What is critical is to continue dialogue underway for several years on engineering. That dialogue has already produced substantial results. And, if conducted in a collegial manner and involving all parties, then we may fashion more effective remedies that will benefit not only engineering but also science and the federal role in research and development.

Mr. Chairman, this finishes my prepared testimony, I'll be most happy to answer your questions. Thank you.

Mr. **Fuqua**. Thank you very much, Dr. Press.

On page 4 of your prepared statement you mention that there is $786 million provided by the Federal Government for basic research in engineering, most of it coming from other agencies than the Foundation. You also, on page 6, I think, allude to that again, that there's only one agency charged explicitly with supporting basic scientific research. There are several, including the Foundation, which support engineering. That other support is $786 million.

How much of that goes to universities for research?

Dr. **Press**. OK. I have that here.

It's very hard to get these statistics out of the complex—for example, mathematics and computer sciences are lumped together, but computer sciences is more appropriately an engineering subject in most schools. But in 1981, R&D expenditures at doctorate-granting institutions—all right, engineering and computer sciences, $1.08 billion.

Mr. **Fuqua**. Million?

Dr. **Press**. Billion.

Mr. **Fuqua**. Billion.

Dr. **Press**. Physical sciences and mathematics, $831 million; biology, not counting medical things, $1.17 billion. That's taken from the National Science Foundation "Academic Science and Engineering R&D Funds, Fiscal Year 1981."

Mr. **Fuqua**. That includes the total Federal effort?

Dr. **Press**. That's total Federal effort.

Mr. **Fuqua**. So then we'd have to break the NSF out from what the——

Dr. **Press**. No; I don't have that here.

Mr. **Fuqua**. Because I was really wondering, of the $786 million, of non-NSF funds, how much of that would go to doctorate——

Dr. **Press**. Well, there may be experts in the room, but I think it's about 140—essentially the total NSF budget in engineering goes to universities, I would gather, most of it.

Mr. **Fuqua**. Right. Well, most of the NSF budget goes to universities.

Dr. **Press**. Right. And, therefore, the NSF budget this year is of the order of $147 million to universities in engineering.

Mr. **Fuqua**. Now that question has been raised, that NSF supports about, say in electrical and mechanical engineering, about 40 percent of the university research while in areas such as chemical and civil engineering, they support nearly 80 percent.

Dr. **Press**. I'm familiar with those figures, and that's why I believe that mission agencies, for which chemical engineering is essential, like NASA, the Defense Department, certainly the Energy Department, have to do more in this area. And that's where I would seek additional funds, as well as the NSF, for engineering.

Mr. **Fuqua** Now there have been those that suggested that areas such as computer and informational sciences, that they may feel like they need to be included.

Dr. **Press**. There's no question about that, and I would like to see a cross-governmental approach to strengthen computer sciences and information sciences.

Mr. **Fuqua**. Now you indicated also in your statement, at the bottom of page 5, that you would oppose the transfer of half of the NSF budget into engineering by legislative fiat. I think it's been clearly demonstrated, and the two sponsors of the amendment are here, that that was not their intention, to do anything of that type. It's just to provide an emphasis that engineering was an important area and include the word "engineering" in the Organic Act, but not to transfer one-half the funds, or science receive one-half and engineering the other half. It would still be the National Science Foundation.

Dr. **Press**. I didn't mean to impute that the subcommittee that's supporting this amendment wanted to do that.

Mr. **Fuqua**. No; I didn't——

Dr. **Press**. I didn't mean to impute that, but the——

Mr. **Fuqua**. I didn't take it that way.

Dr. **Press**. No; I'm glad you didn't take it that way.

But the symbolic partitioning of the NSF between science and engineering in the form of the amendment, where it's absolutely a mirror image—every place you see "science," you see "engineering"; if you have a paragraph devoted to science, there's an identical paragraph, section 3(1) I believe it is, an identical, mirror paragraph specifying engineering. That is a symbolic partitioning, which, although it is not the intent of this committee to have that represent a fiscal partitioning, nevertheless, that is something that will be before us now as part of the Organic Act of the NSF, and I'm sure there will be a tendency by some groups to use that as a means of accomplishing that goal.

Mr. **Skeen**. Will the chairman yield?

Mr. **Fuqua**. Yes.

Mr. **Skeen**. If I might, Dr. Press, there has been some technical amendments submitted by the National Science Foundation that relate directly to the problem that you're talking about. And do you have support for the amendment if they are incorporated? I think you're familiar with the amendments?

Dr. **Press**. Yes.

Mr. **Skeen**. Or with the incorporated technical changes.

We propose to do that, Mr. Chairman.

Dr. **Press**. If the committee decides to go for it and amend the act, then I think the proposal from the National Science Foundation not to introduce a new section 3(2), but to incorporate engineering in an enhanced way in section 3(1), the way Dr. Knapp has suggested in his letter to the committee——

Mr. **Skeen**. These are the technical amendments that we would like to see incorporated to take care of the concerns that you have.

Dr. **Press**. I think that would be a distinct improvement.

Mr. **Skeen**. Thank you very much, Doctor.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you.

Mr. Brown.

Mr. **Brown**. Dr. Press, I can't disagree with much in your testimony. I think we come at this in slightly different directions, but I think you know me well enough and I know you well enough to have you recognize that I'm not trying to reduce the budget for basic science in the National Science Foundation or to dilute it by making half the budget for fundamental engineering research.

Let me ask you this: in a rough way, within the Academy you face similar problems to what we're dealing with here—where you have the Academy of Engineering and the Academy of Science. It's been my impression that you had achieved a cooperative and workable, positive, productive relationship and that neither of the bodies looks invidiously on the other as preempting funding, or anything of that sort.

Am I correct in this?

Dr. PRESS. That's right. Under my administration at the Academy, the Academy of Engineering has been given a partnership role in the operation of the National Research Council.

Mr. BROWN. Are there any parallels here with—my impression was that we have moved in the Foundation to try to develop a partnership role with engineering; that this administration has supported that; that what we are getting is a program which better supports the total national needs than we had before. And it was my feeling that these rather modest language changes merely followed this indication of real change in terms of the role of engineering, did not precede it or force it. But you seem to take a slightly different view here.

Dr. PRESS. I think the parallel with the Academy—I think maybe it should enhance the credibility of my statement, because I worked very hard in the National Research Council to give the engineers a real partnership role, equal votes on the Governing Board of the National Research Council.

But the essential point that I'm trying to make is that the problem of engineering and engineering schools in the country is not the sole problem of the National Science Foundation, which was created as a balance wheel for those fields which do not find support in other Government agencies, and that's basic science.

Engineering is, as you know, an applied science, and just about every agency with a mission in the Government needs applied science engineering. And that's where we should find solutions to the problem of engineering, across the Government, rather than laying it on the National Science Foundation, the way these changes symbolically appear to do.

And I know that your intent—you've always been among the strongest supporters of the National Science Foundation, and your intent is not to partition the funds—nor Representative Skeen's. I agree with that, but I think that there are many elements and pressure groups who will take this proposed change and use it as an authority to move in that direction.

Mr. BROWN. Well, I'm getting to that point. I think you are correct. I think there is a perception, first, in the academic science community, that this conceivably could be threatening and that you are reflecting those views in a very adequate way.

Second, there may be a feeling in the academic engineering and nonacademic engineering field that this is an entering wedge which will allow them to really assume the role that they want to, and there are even a few there that maybe think engineers are better than scientists or something like that, and that it really ought to be a National Engineering Foundation rather than a National Science Foundation. Those are problems.

It's a problem if it's disturbing to the academic science community. It's a problem if it gives false impressions to the engineering community, and we need to deal with those problems in a constructive way. And this hearing contributes to that, in my opinion.

Neither—in my opinion, neither of those situations are based upon fact, neither of those fears or illusions, as the case may be. And what we need to do is to deal with that as a problem, not with this, if in itself these changes are constructive and reflect, rather than force, reflect a real change and a little better balance than is taking place in the Foundation.

I don't want to embarrass you, but I would like to ask you to comment with regard to Dr. White's letter to the committee on this matter suggesting that these changes are a positive step toward invigorating the national engineering research and educational enterprise in academia. You're not really that far apart from Dr. White, are you?

Dr. Press. He and I have talked about this. By the nature of his constituency, he couldn't come here and oppose this amendment. On the other hand, the National Academy of Engineering did not propose it initially, either.

Mr. Brown. Well, by the nature of your constituency, you can't come in here and avidly support it, can you?

Dr. Press. Well, as I said at the beginning of my testimony, every time I've appeared here, if you go back over my testimony, one of the highest priorities of my statements has been the problem of engineering, engineering schools. I've always addressed that issue, because I think it's an important issue.

And I would like to address it in such a way that we don't make more trouble for ourselves in the years ahead in dealing with an agency that has created, I think, the strongest scientific country in the world.

Mr. Brown. Mr. Chairman, would you indulge me for one more comment?

Mr. Fuqua. Quickly.

Mr. Brown. The Foundation, as you know, came out of the recommendations of Dr. Bush after World War II, who originally recommended setting up a National Research Foundation, not a National Science Foundation. And the support that he got for that in the Congress and in the executive branch stemmed from the fact that some engineers took some very important scientific work, like Einstein's, and very quickly converted it into a nuclear bomb, and they converted a lot of scientists into engineers in the process.

I'm only mentioning that not in anyway to demean the tremendous contributions of the scientists, but to indicate that from the inception there was a close tie to engineering in everything that preceded the Foundation, and that its political support was due to the contribution that scientists made in cooperation with engineers to the national welfare.

Now the problem is to maintain that proper balance, Dr. Press. And I'm not trying to lecture to you because I think you understand it very well, but I'm trying to educate, if I can, the broader community outside, which sometimes still doesn't understand this, at least in the sense that I think it should be understood.

Dr. PRESS. I agree with——

Mr. BROWN. Forgive me for that editorializing.

Dr. PRESS. Mr. Brown, I agree with your statement of the history. There's no question that the National Science Foundation was created because—as a result of the war, and so on, and the tremendous power of science and its ability to contribute in applications, in that time military applications, today in our industrial sector and our economic welfare, but that is the basis for supporting science as an endeavor in itself. But from the early days on, the Foundation as created by Dr. Bush and his colleagues emphasized, again, the basic sciences.

Mr. FUQUA. Thank you, Mr. Brown.

Mr. Gregg.

Mr. GREGG. I have no questions.

Mr. FUQUA. Thank you, Mr. Gregg.

Mr. Walgren.

Mr. WALGREN. Thank you, Mr. Chairman.

I would just like to ask—there had been proposals for a technology foundation along the lines that Mr. Brown has outlined—if there might be other ways to approach this.

In the best of possible worlds, how would you organizationally strike the balance that Mr. Brown and yourself have just recognized as so important?

Dr. PRESS. I would gather together the heads, all of the presidential appointees, the senior presidential appointees in R&D across the Government. In fact, there's a body that exists called the Federal Council on Science and Technology, FCST. I would gather FCST together and ask them to fix it, fix engineering across the board by initiatives in this budget on behalf of fellowships, instrumentation programs, equipment for teaching engineering, incentives for young faculty to stay in the engineering schools. And that's why I call for a cross-governmental approach to the solution of this problem.

The other agencies contribute more funding to engineering than does the NSF. You can't load NSF with the problems of engineering exclusively. You need a cross-governmental effort. And I think that can succeed.

Mr. WALGREN. You had mentioned that the National Science Foundation was designed to be the balance wheel to add weight to areas that don't have a natural political constituency.

Dr. PRESS. Or mission, yes.

Mr. WALGREN. Maybe missions is the better word.

How important is it to have a foundation that is sort of exclusively devoted to that particular role with respect to the sciences? Is the idea of a relatively—and I don't have exact words for these things—but a pure science function and responsibility placed in an independent and funded agency, something that you would view as extremely important, or can we do that function in another way, also, in a more broad organizational structure?

Dr. PRESS. The National Science Foundation has evolved over the years, I think, in a constructive way. It doesn't only do pure science. It does science education. It does social science. And increasingly, the most rapid growth division in the National Science Foundation is the engineering component. And I think it has evolved in a constructive way based upon peer review, based upon the needs of the country, and the Organic Act shows it great strength and its flexibility in permitting that growth.

The national—the engineering budgets across the Government have been the largest increasing budgets, even increasing more rapidly than the life sciences, and that shows that we can be responsive; we can do more. But the existing structure has permitted remedial actions to be initiated.

And so I don't consider the National Science Foundation a pure science entity. I think its Organic Act has, in the wisdom of those who drafted it, has permitted the kind of flexibility which has enabled it to evolve in a very constructive way to the strong organization that exists today.

Mr. Walgren. You indicated that this parallel structure could be interpreted to support a division, essentially, or certainly an equal weight being given. Yet that is neither the intent of either the engineering community sponsors, who have said that they're not really interested in dollars, and both Mr. Skeen and Mr. Brown, who have said that the purpose here is not to create some kind of a division.

Could you estimate the probability of resources being drawn from the sciences to engineering, to the real detriment of the sciences, by this kind of Organic Act language? Now I know we can say, well, it might not happen, and it might not happen, but can you make some estimate of the probability of what you would expect to happen?

Dr. Press. No, I couldn't do that, and it may not happen. I think the main point I'm trying to make is the following: This amendment, which provides absolutely perfect symmetry—it's as if you're partitioning the Science Foundation between science and engineering—if you wanted to make such a partition, you couldn't do it better than going through the bill and every place you see "science" you give equal weight to "engineering." Every paragraph associated with science has a duplicate paragraph, word for word, with the word "engineering" replacing "science" as an additional paragraph. And I think that way of doing it sets the National Science Foundation up with its Organic Act to pressure groups coming back saying, "Well, here's the authority. The act, the Organic Act, has been changed in such a symmetrical fashion. We now want to increase the funding of engineering as is symbolically or philosophically represented by this statement."

That may not happen, but it's an invitation for that kind of process. And instead of the evolution of the National Science Foundation based on national need and merit and peer review, which has led to the strong organization we see today, there will be shortcuts proposed or there can be shortcuts proposed—there may not be, but there can be shortcuts proposed on the basis of this change.

This is not the intent of the subcommittee, and I agree with the subcommittee's statement that it was not their intent, but I think it will be used that way, the way it is being cast right now.

Mr. Walgren. Thank you, Mr. Chairman.

Mr. Fuqua. Thank you, Mr. Walgren.

Mr. Skeen.

Mr. SKEEN. Thank you, Mr. Chairman.

Dr. Press, I appreciate your feeling, and it certainly was not—I don't know you as well as Congressman Brown does, but we've had some association, and I can assure you that my feeling runs very much parallel with Mr. Brown.

And you mentioned several times pressure groups, and we deal with these folks every day, including those dedicated to the purity of science, and they are just as potent as those who represent engineering interests. I think there's probably a good balance.

But, once again, I think that rather than yielding to pressure groups or trying to construct a piece of legislation that could be abused—the intent was not to abuse the use. I'm saying there's a question, and we were trying to get equity in this thing along with all the other fine, altruistic intentions that you always have. Of course, sometimes in the crafting of these, they are—they can be abused. I really appreciate your concern.

But I'd like to ask you, Do you believe that the engineering research that's supported by the mission-related agencies is similar to the fundamental broad-based research which is supported and appropriate within the National Science Foundation?

Dr. PRESS. In the mission agencies a test is applied about relevance, and that's correct. And that's why I think that the National Science Foundation should also be a balance wheel for basic engineering research, the way it is now. I think the some $270 million, whatever, represents that balance wheel.

But materials research, computers research, artificial intelligence, applied mathematics—you find support in these fields in the Defense Department, going to universities, in the Energy Department, in NASA certainly, and through other departments of government. And engineering has that advantage, has the advantage of having its basic aspects supported in the National Science Foundation and its more applied aspects—and engineering is an applied field—supported in the mission agencies, not enough, but it has that diversified base of support that some pure fields of science do not have. And it hasn't been unsuccessful.

In the 10 years—in the 9 years, 1971 to 1980, the average annual percentage change in engineering is bigger than any field of science, even life sciences, 16 percent. And the nearest contender is life sciences, something like 12 percent.

From science indicators this past year, when discounted for the effects of inflation, engineering fields were the only science and engineering disciplines where real growth occurred, up to 18 percent in the 1980-81 period. And since that time, the growth has been comparable.

And the reason for that is the fact that engineering is spread across the Government, including the National Science Foundation, and it has the opportunity to—because of that diversified support—to grow in the way that it should, not that this is enough but the mechanism is in place to do right by engineering and engineering schools without this profound change in the Organic Act.

Mr. SKEEN. Would the converse be also within the realm of possibility, Dr. Press, that with this—and, of course, again I think that engineering is no longer defined as an absolute applied science as opposed to a basic. I think that's the problem we're trying to deal with: Is the change in the kinds of technology involved, and so forth.

But would it not also work the other way with this focus on engineering and the technological advances that would accrue to the benefits of the so-called basic scientists—sciences as well, because I don't want to see funding pulled out by this mechanism of changing or amending this Organic Act. It was not our intent whatsoever to cause this to be a raid on funds. If the only question involved is where the funding is going to go, is this going to be an excuse to relieve basic sciences of funding, and so forth—I would not have been in favor of it.

Dr. PRESS. I understand.

Mr. SKEEN. I don't think that's the original thrust.

I appreciate your honest approach to this thing very much. And once again, I think that's the value of these hearings.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Skeen.

Mr. McCandless.

Mr. McCANDLESS. Thank you, Mr. Chairman.

I'm still looking for a cure for the common cold. Dr. Press, if you find one, let me know, will you? [Laughter.]

It's been the practice of the National Science Foundation to select research projects based solely on the scientific merit of the proposal, and those projects seem to find their ways into universities and not into industrial complexes, unless there happens to be some kind of a unique circumstance.

And so my question is that. Would not the support of industrial proposals on a less restricted basis be a way of better translating this basic research into an ultimate engineering practice?

Dr. PRESS. Are you talking about small business or industry as a whole?

Mr. McCANDLESS. Well, we go back to the basic thought that I advanced, and that was the selection of research projects.

Dr. PRESS. I see.

This past year research and development investments by American industry exceeded that of the U.S. Government for the first time, I think, since the 1960's. I think industry itself is now investing so heavily in R&D in its own interest and as an investment in the future of American industry that there may not be the need for the Government to be a participant.

On the other hand, when you come to the fields we have been talking about—basic engineering, science—there is no alternative but the Government to serve as the national patron for the support of science and basic engineering.

And so I think it's one of the best indications that we as a Nation will be competitive in the years ahead that industry is using its own funds, its own profits, to plan for the future by heavy investments in research and development.

Mr. McCANDLESS. Can these projects at the university level that are funded, basic research funded by the Foundation, in your opinion, find their way into a finished product through the engineering process to the degree necessary based upon the number of projects, the number of man-hours, the amount of funding that resulted in the finished scientific research projects?

Dr. **Press**. I think that's a key question. It surprises a lot of people to learn that in the United States we have the best record of technology transfer from science to commercial products. We're the envy of the French, the English, the Germans, and even the Japanese. And we do that by a number of mechanisms.

There is the professor-consultant. Most of the American scientists and engineers in universities spend some time consulting. That's an extremely efficient technology transfer mechanism that is almost exclusive to the United States. You don't find that in other countries where universities tend to be ivory tower institutions.

The growing relationships between American industry and universities through sponsored research, through these new targeted and yet acceptable industrial contributions to universities, is again unique to the United States and is a very healthy development.

There are many examples that one can cite. The biotechnology revolution in which we have the potential for leading the world originated in the American university system supported on Government funds, and that's going to be a multibillion-dollar industry within this decade. So although we can improve, at the present time we're the model for the rest of the world.

I think where we really need to improve—and this is something that's important for engineering—is in our ability to manufacture things productively and with high quality. And I hope that the engineering schools start producing the kinds of engineers that know about design and manufacturing, and that I think is the key element that might inhibit us in the years ahead.

Mr. **McCandless**. Thank you, Dr. Press.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. McCandless.

Mr. Bateman.

Mr. **Bateman**. Thank you, Mr. Chairman.

Dr. Press, I, too, want to express the appreciation of this member of the committee, for your being here this morning and sharing your views, your concerns, with us. I've listened and then reread your comments, that at the foot of page 7 of your statement, to the effect that what is critical is to continue to dialog underway for several years on engineering. "That dialog has already produced substantial results and, if conducted in a collegial manner and involving all parties, then we may fashion more effective remedies that will benefit not only engineering, but also science and the Federal role in research and development." That's certainly a statement that I applaud, and I think certainly all of us would want to encourage that collegial dialog of which you spoke.

I find, from discussion that took place at the subcommittee level, and I really haven't seen anything inconsistent with that today, that basically what the Skeen amendment is trying to do is to recognize the fact that that collegial dialog that encompasses the basic engineering should be recognized and encouraged. And it's my view that that's what the Skeen amendment does—is to give congressional recognition to the fact that this is something to be promoted and encouraged. I don't think, to my mind, it implies that it is not taking place. I am not registering some dissatisfaction by having supported the Skeen amendment.

It would seem to me that the Skeen amendment is making a modest change in the Organic Act, recognizing something that exists and should continue to exist, because that in fact is what has happened out there.

Could you give me your comments to my comment?

Dr. PRESS. I think the intent of the subcommittee was a very reasonable one—just as you said, not to have engineering become the overwhelming factor in the National Science Foundation, but to recognize that there's a certain national problem and it has to be corrected.

But I think the way the amendment was cast, that there will be an external perception that something more was intended. This was not the subcommittee's intent, but if you read the way it was done, the perception has to be that there is essentially a partitioning of the National Science Foundation between science and engineering, because that's what you have done. You have taken the Organic Act and every place where you see "engineering," you're inserting "science." In every paragraph that is dedicated to science you're dedicating a new paragraph to engineering.

The public perception has to be that there's something deeper involved, even though the fact may not be the case.

Mr. BATEMAN. I appreciate that observation.

And let me conclude, Mr. Chairman, just with this comment: I guess as legislators, our greatest satisfaction comes from participating in some change in the law which affects some quantum leap in public policy that is looked upon as being good or desirable. Unfortunately, in a sense unfortunately, I don't look upon the Skeen amendment as one of those opportunities for making some sort of a quantum leap. I view it as something where, as you have pointed out, there has been some increased support and enhancement by the Federal Government of engineering.

I think we are recognizing a fact of life through the Skeen amendment—that there is a very important role that has been and must continue to be played in terms of basic engineering and enhancement of education in basic engineering, and that we're not making some sort of a quantum leap. We are not making some egregious change in the structure of the National Science Foundation by having the statute, itself recognized a legitimate and appropriate collegial atmosphere as it relates to disciplines, that you and others can define better than I as basic engineering.

And with that, I thank the chairman.

Mr. FUQUA. Thank you, Mr. Bateman.

Mr. Boehlert.

Mr. BOEHLERT. No questions.

Mr. FUQUA. Thank you very much, Mr. Boehlert. You're a gentleman and a scholar. You got the hint. [Laughter.]

Mr. BOEHLERT. That's in the record? [Laughter.]

Mr. FUQUA. Mr. Lowery.

Mr. LOWERY. No questions.

Mr. FUQUA. Thank you very much, Dr. Press. We appreciate your being here this morning and sharing with us your and the Academy's views.

Our next two witnesses: Dr. Thomas Ratchford, associate executive director of the American Association for the Advancement of Science, and Dr. Rosenzweig, president of the American Association of Universities.

Tom, we're very pleased to have you sitting on that side of the table again, and welcome back.

[A biographical sketch of Dr. Ratchford follows:]

Biographical Information of J. Thomas Ratchford

Dr. J. Thomas Ratchford has served as Associate Executive Officer of the American Association for the Advancement of Science (AAAS) since 1977.

Educated and trained as a solid-state physicist, he taught at Washington and Lee University and has served on research staffs of various private and government laboratories. From 1964 to 1970 he was responsibile for formulating and administering a basic research program in the solid state sciences for the Office of Scientific Research of the Department of the Air Force. Dr. Ratchford was Science Consultant to the Committee on Science and Technology of the United States House of Representatives from 1970 to 1977, and was one of the first scientists to serve the Congress on a full-time basis. His responsibilities with the Congress dealt mainly with science policy and energy technology.

A Congressional Fellow of the American Political Science Association during 1968-69, he served in the office of Members of the House and Senate with particular interests in scientific and technological issues. Dr. Ratchford spent the summer of 1976 as a Research Scholar at the International Institute of Applied Systems Analysis in Laxenburg, Austria, doing research on the economics and technology of global energy systems. Over the years he has chaired outside advisory panels for the Gas Research Institute and the Congressional Office of Technology Assessment, and served as consultant to governmental, university and industrial organizations.

Dr. Ratchford received his B.S. in mathematics and physics from Davidson College in 1957. The University of Virginia awarded him a M.A. in 1959 and a Ph.D. in physics in 1961. A member of Phi Beta Kappa and Sigma Xi, he is a Fellow of the AAAS and a member of the American Physical Society.

STATEMENT OF DR. J. THOMAS RATCHFORD, ASSOCIATE EXECUTIVE OFFICER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. Ratchford. Thank you very much, Mr. Chairman.

Your side of the table is the preferable one.

It's a real pleasure to appear before this committee to discuss a proposed engineering amendment to the Organic Act of the National Science Foundation.

My name is Tom Ratchford. I serve as associate executive officer of the American Association for the Advancement of Science.

My comments today are my own, rather than those of the AAAS board of directors or council. They are, however, consistent with the views of our president, Dr. Anna Harrison, and chief executive officer, Mr. William Carey, who could not be here today.

Founded in 1848, AAAS has about 135,000 members in all branches of science and engineering. It is also the world's largest federation of scientific and engineering societies, with some 285 affiliated organizations. Among scientists and engineers, it is best known for its journal, "Science," founded by Thomas Edison in 1880.

The committee has before it today the Skeen substitute, a vehicle for explicitly recognizing the important roles which fundamental engineering research and engineering education play in the programs of the National Science Foundation. In some ways this proposed amendment to the NSF Organic Act is similar to that in the late 1960's, which permitted NSF to support applied scientific research. That initiative, like this, came from the Congress.

Former AAAS president Emilio Q. Daddario, then chairman of the subcommittee which was the lineal ancestor of the present Subcommittee on Science, Research and Technology, authored what some perceived to be a radical change to the NSF charter. Mr. Daddario's legislation broadened the powers and responsibilities of the Foundation to applied work. Some years later, Mr. Daddario stated, "The intent of the 1968 law was not to weaken the Foundation's support of basic research but to bolster it." I would hope the Skeen amendment will also result in strengthening basic scientific research at NSF through broadening the base of public support for the Foundation.

There were concerns then, as now, that change would divert resources from basic scientific research. But the history of applied research at NSF indicates otherwise. There were false starts, even failures, along with the successes. Over the years, however, support for growth in the NSF budget has gained in the House and the Senate because of the new applied research initiatives. Today we find the Foundation is still overwhelmingly basic in its research orientation as a result of the ongoing budget decisions made over the past 15 years. In fiscal year 1985, for example, the proposed budget has only about 7 percent of its research funds in other than basic endeavors.

There are important differences as well as similarities between the proposal before the committee today and the 1968 amendments. First and foremost, the Skeen substitute will not license NSF to do anything it cannot do or is not doing already. The Organic Act clearly considers engineering to be a member of the family of science. This is consistent with Webster's Third International Dictionary, which gives as its first definition of science: "Possession of knowledge as distinguished from ignorance or misunderstanding." This certainly includes engineering.

As one works through to the fifth definition, we find it reads, "a system based or purporting to be based on scientific principles; a method reconciling practical or utilitarian ends with scientific laws." This sounds like engineering to me.

In our universities the boundaries between science and engineering have become increasingly blurred in recent years. Tangible evidence of this can be found in the similarity between research programs in electrical engineering and solid state physics, as well as in other areas.

NSF today has a strong program of fundamental engineering research, of which the engineering community and the Foundation can be justly proud. What the Skeen substitute provides, as I read it, is a more explicit recognition of the importance of engineering and emphasis on its support by NSF. The added recognition is well-deserved. Engineering today is much more than just applied science. During the past 15 years there have emerged areas of research—fundamental in nature—that cannot be forced into the mold of traditional science classification schemes. It is appropriate to recognize this research for what it really is: fundamental engineering research.

AAAS over the past few years has also recognized engineering in the titles of a number of its committees and programs. For example, our Committee on Science, Engineering and Public Policy formerly did not have engineering in its title; Likewise, the AAAS mass media science and engineering fellows program.

The budget for engineering research at NSF is rapidly increasing. The changes in the Organic Act proposed by the substitute recognize this reality and provide further legitimacy. The changes before the committee today do not, however, deal with funding levels. They should not, and special set-asides in the future should be avoided. The funding of engineering research, like that in the basic sciences, must emerge from the annual NSF authorization and appropriation cycle, with all the give and take that implies.

The Skeen substitute also ties engineering research and education to industrial development. This should help in building closer ties between academic research supported by NSF and our industrial companies, although I would not want to be first in line to appraise the impact of such research upon industrial research and upon the general welfare. That will be a very tough job.

Over the years, Mr. Chairman, I have learned to appreciate the beauty and lyricism of legislative etymology. Consequently, I am reluctant to comment on the specific language before the committee, except to say that it reads well and gets the job done. There are three specific changes wrought by the amendment, however, that I should like to address briefly.

First, section 3(c) of the NSF Organic Act would be changed to authorize the NSF, when so directed by the President, to support applied scientific and engineering research relevant to national problems * * * This is not fundamental engineering research, and should be scrutinized carefully. I have personal doubts as to the wisdom of the proposed changes in this particular subsection.

Second, section 11(g) would be changed to read, "publication of scientific or engineering and technical information * * *." Replacing the new "or" by a comma makes the phrase read smoother.

Third, in some places where "engineering" is substituted for "technical," I would suggest adding "engineering" and retaining "technical" as well. For example, in the renumbered section 3(a)(7), one might see a need for, "data on the availability of, and the current and projected need for, scientific, engineering and technical resources * * *." This triad of expertise—scientific, engineering, and technical—is especially relevant in fields such as computer applications.

Mr. Chairman, last month AAAS president Anna Harrison testified before the Science Subcommittee on the fiscal year 1985 NSF budget request. In her testimony Dr. Harrison spoke of the unity of science and engineering, and stated that, "the AAAS would support the investigation of mechanisms to bring science and engineering closer together in Federal agencies." The Skeen substitute does this for one such Federal agency, and I am pleased to support it.

Thank you.

[The prepared statement of Dr. Ratchford follows:]

Statement by

J. Thomas Ratchford

Associate Executive Officer

American Association for the Advancement of Science

on

A Proposed Engineering Amendment

to the NSF Organic Act

It is a pleasure to appear before this Committee to discuss a proposed engineering amendment to the Organic Act of the National Science Foundation (NSF). My name is Tom Ratchford. I serve as Associate Executive Officer of the American Association for the Advancement of Science (AAAS). My comments today are my own, rather than those of the AAAS Board of Directors or Council. They are, however, consistent with the views of our President, Dr. Anna Harrison, and chief executive officer, Mr. William D. Carey, who was unable to be here today.

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There were concerns then, as now, that change would divert resources from basic scientific research. But the history of applied research at NSF indicates otherwise. There were false starts, even failures, along with the successes. Over the years, however, support for growth in the NSF budget was gained in the House and Senate because of the new applied research initiatives. Yet, today, we find the Foundation is still overwhelmingly basic in its research orientation as a result of the on-going budget decisions made over the past 15 years. In fiscal year 1985, for example, the proposed budget has only about 7% of its research funds in other than basic endeavors.

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NSF today has a strong program of fundamental engineering research, of which the engineering community and the Foundation can be justly proud. What the Skeen Substitute provides, as I read it, is a more explicit recognition of the importance of engineering and emphasis on its support by NSF. The added recognition is well-deserved. Engineering today is much more than just applied science. During the last 15 years there have emerged areas of research - fundamental in nature - that cannot be forced into the mold of traditional science classification schemes. It is appropriate to recognize this research for what it really is: fundamental engineering research.

AAAS over the past few years has also recognized engineering in the titles of its Committees and programs. For example, our Committee on Science, Engineering and Public Policy formerly did not have engineering in the title; likewise the AAAS Congressional Science and Engineering Fellows Program and our Mass Media Science and Engineering Fellows Program.

The budget for engineering research at NSF is rapidly increasing. The changes in the Organic Act proposed by the Substitute recognize this reality and provide further legitimacy. The changes before the Committee today do not, however, deal with funding levels. They should not, and special set-asides in the future should be avoided. The funding of engineering research, like that in the basic sciences, must emerge from the annual NSF authorization and appropriation cycle, with all the give and take that implies.

The Skeen Substitute also ties engineering research and education to industrial development. This should help in building closer ties between academic research supported by NSF and our industrial companies, although I would not want to be first in line "to appraise the impact of such research upon industrial research and upon the general welfare." That will be a tough job.

Over the years, Mr. Chairman, I have learned to appreciate the beauty and lyricism of legislative etymology. Consequently I am reluctant to comment on the specific language before the Committee except to say that it reads well and gets the job done. There are three specific changes wrought by the amendment, however, that I should like to address briefly.

First, Section 3(c) of the NSF Organic Act would be changed to authorize the NSF, when so directed by the President, to support "applied scientific and engineering research relevant to national problems..." This is not fundamental engineering research, and should be scrutinized carefully. I have personal doubts as to the wisdom of this particular change.

Second, Section 11(g) would be changed to read "publication of scientific or engineering and technical information.." Replacing the new "or" by a comma makes the phrase read smoother.

Third, in some places where "engineering" is substituted for "technical," I would suggest adding "engineering" and retaining "technical" as well. For example in the renumbered Section 3(7), one might see a need for "data on the availability of, and the current and projected need for, scientific, engineering and technical resources..." This triad of expertise - scientific, engineering and technical - is especially relevant in fields such as computer applications.

Mr. Chairman, last month AAAS President Anna Harrison testified before the Science Subcommittee on the Fiscal Year 1985 NSF budget request. In her testimony Dr. Harrison spoke of the unity of science and engineering, and stated "the AAAS would support the investigation of mechanisms to bring science and engineering closer together in federal agencies." The Skeen Substitute does this for one such federal agency, and I am pleased to support it. Thank you.

Mr. **Fuqua**. Thank you very much, Tom.

And now, Dr. Rosenzweig, we would be pleased to hear from you at this time.

STATEMENT OF ROBERT M. ROSENZWEIG, PRESIDENT, ASSOCIATION OF AMERICAN UNIVERSITIES

Dr. **Rosenzweig**. Thank you, Mr. Chairman.

I think I appreciate your invitation to take another crack at this issue this morning, and I apologize for not having gotten a copy of my statement up to you in advance. That was not intentional; it was inevitable, I'm afraid. It does, I note, have the advantage of limiting hostile fire early on. Perhaps it's not a bad practice generally.

Let me note for the record, Mr. Chairman, that I'm appearing here this morning on behalf of the Association of American Universities, the American Council on Education, the National Association of State Universities and Land-Grant Colleges, the American Association of State Colleges and Universities, and the Council of Graduate Schools.

In my earlier testimony to the Science and Research Subcommittee of this committee, I indicated my opposition to the proposed amendment that was then before the subcommittee. It seemed unnecessary, and it opened precedents for favored treatment for other disciplines that would be hard to resist and unwise to grant.

Moreover, and perhaps even more importantly, the NSF Organic Act has served science well for almost 35 years. In all that time there has been the need for only one major review of its provisions. We strongly believe that amendments ought to be weighed carefully and deliberately and that proposals for other than necessary technical amendments—technical improvements—ought to be considered apart from the annual authorization process.

However, the amendment before the committee now is different and less troublesome. The place of engineering research and training on the national agenda has been established by the rapid growth in the intellectual challenges of fundamental engineering research and by the importance attached to technology broadly throughout the Nation. These circumstances are now reflected in the working organization of NSF, in NSF funding levels, and in the research programs of the various mission agencies. Changing the language of the act will not improve matters for engineering; failing to change it will not jeopardize the gains that have been made.

I make that point, Mr. Chairman, because the most serious reservation expressed by the university presidents with whom I have spoken is that no amendment should be adopted if it is likely to be interpreted in such a way as to require a shift in funding priorities from basic scientific research toward more applied work aimed at the solution of nearer-term problems. A few would oppose the proposal based on that concern alone. Most, however, do not believe that a shift in funding priorities would result from adoption of the proposed language.

We are pleased to see that the proposal does not mandate statutory floors, set-asides, or other directed forms of support.

If the changes are adopted, we trust that the legislative history will make it clear that no such purposes are intended. The ability of the Foundation and the National Science Board to support excellence, to pursue new opportunities, and to assure stable investment policies for basic scientific research across all disciplines, including fundamental engineering science, is essential to the long-term health of American science. We would hope that the committee will continue to resist any efforts to restrict the Foundation's ability to invest in science of the highest quality in whatever fields are the most promising.

It is altogether unlikely that the Foundation will withdraw from its commitments to basic engineering research and training. That being so, there is no compelling reason to oppose language that reflects that fact, so long as it is clear that the language imposes no obligation on the Foundation to act in ways other than those that are dictated by the best scientific judgments. If I am correct that the new language would cause no change, but merely reflects changes already made, then it seems to me unobjectionable.

Thank you, Mr. Chairman.

[Prepared statement of Dr. Rosenzweig follows:]

TESTIMONY

BY

ROBERT M. ROSENZWEIG

PRESIDENT, ASSOCIATION OF AMERICAN UNIVERSITIES

Mr. Chairman and Members of the Committee, for the record, let me indicate that I am appearing here this morning on behalf of the Association of American Universities, the American Council on Education, the National Association of State Universities and Land-Grant Colleges, The American Association of State Colleges and Universities, and the Council of Graduate Schools.

In my earlier testimony to the Science and Research Subcommittee of this Committee I indicated my opposition to the proposed amendment that was then before the Subcommittee. It seemed unnecessary, and it opened precedents for favored treatment for other disciplines that would be hard to resist and unwise to grant. Moreover, and perhaps even more importantly, the NSf Organic Act has served science well for almost 35 years. In all that time there has been the need for only one major review of its provisions. We strongly believe that amendments ought to be weighed carefully and deliberately and that proposals for other than necessary technical improvements ought to be considered apart from the annual authorization process.

However, the amendment before the Committee now is different and less troublesome. The place of engineering research and training on the national agenda has been established by the rapid growth in the intellectual challenges of fundamental engineering research and by the importance attached to technology broadly throughout the nation. These circumstances are now reflected in the working organization of NSF, in NSF funding levels, and in the research programs of the various mission agencies. Changing the language of the Act will not improve matters for engineering;

failing to change it will not jeopardize the gains that have been made.

I make that point, Mr. Chairman, because the most serious reservation expressed by the university presidents with whom I have spoken is that no amendment should be adopted if it is likely to be interpreted in such a way as to require a shift in funding priorities from basic scientific research toward more applied work aimed at the solution of near-term problems. A few would oppose the proposal based on that concern, alone. Most, however, do not believe that a shift in funding priorities would result from adoption of the proposed language. We are pleased to see that the proposal does not mandate statutory floors, set asides, or other mandated forms of support. If the changes are adopted, we trust that the legislative history will make it clear that no such purposes are intended. The ability of the Foundation and the National Science Board to support excellence, to pursue new opportunities, and to assure stable investment policies for basic scientific research across all disciplines, including fundamental engineering science, is essential to the long term health of American science. We would hope that the Committee will continue to resist any efforts to restrict the Foundations's ability to invest in science of the highest quality in whatever fields are the most promising.

It is altogether unlikely that the Foundation will withdraw from its commitments to basic engineering research and training. That being so, there is no compelling reason to oppose language that reflects that fact, so long as it is clear that the language imposes no obligation on the Foundation to act in ways other than those that are dictated by the best scientific judgments. If I am correct that the new language would cause no change, but merely reflects changes already made, then it seems to me unobjectionable.

Mr. **Fuqua**. Thank you very much, Dr. Rosenzweig.

Is there a consensus among the deans of the colleges of engineering or deans of engineering among your member institutions as to their position on this?

Dr. **Rosenzweig**. I know that only through talking to my presidents. I assume they've talked to their engineering deans, although one never knows for certain.

As I've indicated, there are some strong concerns about the proposed amendment, but in general the feeling is as I have described it, that it does not harm and, therfore——

Mr. **Fuqua**. The revised amendment that was added in subcommittee?

Dr. **Rosenzweig**. That is correct.

Mr. **Fuqua**. Tom, you mentioned in your testimony that there has been some of your committees within the AAAS that modified the titles of their subcommittees. Has that created any problem where it felt like more emphasis was being placed on one discipline than another?

Dr. **Ratchford**. No. We have had no problems. And, in fact, generally these changes have been enthusiastically embraced by the scientists as well as the engineers.

Mr. **Fuqua**. Thank you.

Mr. Brown.

Mr. **Brown**. Mr. Chairman, I don't think that I have any questions. I think, Dr. Rosenzweig, you again are reflecting here the—and it's important that we do keep it in mind—the concern of those, many of those in the scientific community that this not be construed as an effort to make major shifts in the patterns and priorities of funding.

And I would just like to comment to you, as I did to Dr. Press, that to the degree that there are fears that exist, we don't think they're warranted, and that we should look upon this as an opportunity to try and elevate the consciousness of all the parties involved here to the fact that what we're trying to do is to integrate the needs of the country in a higher way; that is, to bring about a sense that there is a partnership necessary here in order to serve the national need, and that we're not trying to create divisions; we're trying to create partnerships.

If we can all help to do that, I think the country will be strengthened and the relationship between all of the disciplinary and specialized partners in this operation can function more effectively.

I think it will take a process of time because nobody who is satisfied with the status quo likes to feel that it's being disrupted to their disadvantage. I don't want this action to be perceived in that fashion, and I hope you'll help us to achieve that understanding.

Dr. **Rosenzweig**. Thank you, Mr. Brown. I appreciate those views.

The concerns, such as they are, don't have to do with the present or with actors who are presently on the scene. They're addressed to the future. And, in fact, you and your colleagues on the committee are better able to judge than I am, or my associates and universities, how future administrations and future Members of Congress are likely to respond to appeals that may be made to them based on the new language. I can't assess that for you. I'll hope you'll consider that, though, you and your colleagues will consider that as you consider this language.

Mr. **Brown**. Yes. Well, I do consider it. In this connection, I appreciate the historical references of Dr. Ratchford because he was here when we went through this procedure, and I will tell you that the feelings in the Congress 15 years ago with regard to the significance of reemphasizing applied research was greater probably than the feelings that exist today. The situation today is more complex actually, considerably more complex.

But the same fears were expressed—that even though this might be desirable, what would be the long-range consequences? Of course, as Dr. Ratchford has pointed out, those fears did not eventuate—they were not justified in the long range, although they could have been, and they could be today. But that's a problem we always have with us.

We could face the problem of losing congressional support for basic science research in the future at some point. We see signs of that all the time—with attacks upon the nature of some of the research that the Foundation is funding. And this committee has to defend that research year after year for its fundamental importance, and there could be—I hope there never will be—a time when the Congress would say, "Well, that's just not sufficiently in line with the needs of this country," and they'll cite some ridiculous title, you know. They know nothing about the research but they make those judgments on very superficial grounds. We don't want that to happen, either, and it will require continued effort to maintain the health of the enterprise.

Mr. **Fuqua**. Mr. Gregg.

He's not—Mr. Skeen.

Mr. **Skeen**. Thank you, Mr. Chairman.

Dr. Ratchford, Dr. Rosenzweig, I appreciate the comments that both of you have made.

Dr. Ratchford, recognizing some experience that you've had on this side of this building, why, I can certainly appreciate the technical amendments that you've offered.

Those that we had agreed to, that the National Science Foundation had offered, incorporates one of your improvements in the thing and the other two do not. And I see no reason not to incorporate them, and I appreciate very much having them.

Mr. **Brown**. Would the gentleman yield to me at that point?

Mr. **Skeen**. Yes.

Mr. **Brown**. I meant to comment, also. I think Dr. Ratchford's suggestions are meritorious, although I'd like to study the first one a little bit more. I think I might not agree with him, but certainly the second and third I do agree with him on. And when we mark this bill up tomorrow, maybe we can consider those.

Mr. **Skeen**. I appreciate the gentleman's contribution in that area, and that's exactly what we'd like to do, and appreciate the contribution Dr. Ratchford made.

I want to state, once again, that we can reflect in the report language or all the way through the congressional record and the history on this amendment, that we did not intend any partitioning; we did not intend in anyway to shift—to cause a shift of funding of things of that kind.

And I would also pledge to you that we'll see that the language does reflect that that intent is clearly spelled out.

And, once again, I think that this is not an attempt to denigrate or cause any diminution of anybody's effort in the science and engineering fields, but it was to enhance it. We think that it does, and I hope to take the positive side of this thing and feel that we have advanced it. If it has not, then I will be saddened because then I would just as soon not have offered it.

But, thank you very much for your contributions, both of you, and I appreciate them. And I will take the pains to see that we offer the technical amendments—the amendments and so on—and that the report language does reflect exactly what we intended to do.

Thank you very much, Mr. Chairman.

Mr. FUQUA. Thank you very much, Mr. Skeen.

And let me thank you, Tom, for being here, and, Dr. Rosenzweig, we appreciate you being here today.

Our next panel will be Dr. Myron Tribus, representing the National Society of Professional Engineers, and Dr. Donald Glower, representing the engineering education task force and the dean of the school of engineering at Ohio State University.

Is Dr. Tribus here?

[No response.]

Mr. FUQUA. I understand he's testifying before another committee and will be here shortly.

So, Dr. Glower, we'll be pleased to hear from you at this time.

[A biographical sketch of Dr. Glower follows:]

BRIEF RESUME
1983

NAME: Donald D. Glower
2338 Kensington Drive
Columbus, Ohio 43221
Home Phone: (614) 488-5033
Office Phone: (614) 422-2836

POSITION: Dean, College of Engineering
Director, Engineering Experiment Station
The Ohio State University

PERSONAL: Born July 29, 1926 in Shelby, Ohio
Married, four children
Social Sec. No.: 296-22-7596

DEGREES:
BS - Marine Engineering, U.S. Merchant Marine Academy, Kings Point, New York, December 1946.
BS - Antioch College, Yellow Springs, Ohio, June 1953.
MS - Mechanical Engineering, Iowa State U., Ames, Iowa, June 1958.
PhD - Nuclear Engineering, Iowa State U., Ames, Iowa, Nov. 1960.

HONORS: Texnikoi; Sigma Xi; Tau Beta Pi; Theta Tau, distinguished engineer honorary membership; NSF Science Faculty Fellow, 1959-60; U.S. Merchant Marine Academy, Outstanding Business Achievement Alumni Award, 1961; Fellow, American Nuclear Society, 1977; Outstanding Professional Achievement Award, Iowa State U., 1979; Technical Council of the Univ. of Bridgeport, 1982-.

DIRECTORSHIPS:

American Society for Engineering Education, 1975-78.
The Edward Orton Jr. Ceramic Foundation, 1976-.
Transportation Research Center of Ohio, 1976-.
OSU Engineering Experiment Station, 1976-.
National Regulatory Research Institute, 1977-.
OSU Development Fund, 1979-.
Mbr. & Secretary, Industrial Technology and Enterprise Board of Ohio, 1982-.

BIOGRAPHICAL REFERENCES (abbreviated listing):

WHO'S WHO IN ENGINEERING; WHO'S WHO IN THE U.S.; ENGINEERS OF DISTINCTION; WHO'S WHO IN ATOMS; WHO'S WHO IN GOVERNMENT; MEN OF ACHIEVEMENT; AMERICAN MEN OF SCIENCE.

PROFESSIONAL EXPERIENCE:

Dean, College of Engineering and Director, Engineering Experiment Station, The Ohio State University. July 1976 to present.

Professor and Chairman of the Department of Mechanical Engineering, The Ohio State University. July 1968 to 1976.

PROFESSIONAL EXPERIENCE (continued):

Professor of Mechanical and Nuclear Engineering and Chairman of the Nuclear Engineering Committee of the College of Engineering of The Ohio State University. October 1964 to 1968.

Senior executive with the AC Electronics Division of the General Motors Corporation, Milwaukee, WI. December 1963 to October 1964.

Staff member, Radiation Effects Division, Research Directorate, Sandia Corp., Albuquerque, NM. June 1961 to December 1963.

Assistant Professor of Nuclear Engineering and Officer of Instruction in the Graduate College, Iowa State U. September 1960 to June 1961.

Student and Instructor, Iowa State U., Ames, IA. 1949-1960.

Licensed Engineering Officer, Grace Lines, Inc., Moore-McCormick Steam Ship Company, et al. December 1946 to August 1949.

CONSULTING EXPERIENCE:

Massachusetts Institute of Technology, 1964-68.
General Motors Corporation, 1964-68.
Wright-Patterson Air Force Base, 1964-72.
Ballistic Missile Division, U.S. Air Force, 1964-68.
Battelle Memorial Research Institute, 1965-68.
The Martin-Marietta Company, 1966-70.
Goodyear Atomic, 1968-present.
Public Utilities Commission of Ohio 1974-78
BDM Corporation, 1975-present.
Governments of Mexico, 1979-; China, 1980-; Egypt, 1980-present.
UNESCO, Paris, 1981-present.
Various members of the Ohio legislature and the U.S. congress.

PAPERS AND PUBLICATIONS:

Patents: 2,822,824, D. D. Glower, et al., Fluid valve.
Patents Applied For: Ferroelectric Radiation Detector, 1970.
Ferromagnetic Radiation Detector, 1970.
Books and Published Technical Articles:
Four books and over 60 technical articles.

PROFESSIONAL ACTIVITIES (abbreviated list):

Chairman, ASME Region V, M.E. Department Heads Committee, 1973-74.
Member, Engineering Education & Accreditation Com. of ECPD, 1974-80.
Held most offices in Columbus Section of ASME.
President of Columbus Technical Council, 1973-74.
Chairman, Nuclear Engineering Division of ASEE, 1971-72.
Member, ASEE Council for Professional & Technical Education, 1972-.
Member, ASME Power Division Education & Research Committee, 1974-.
Member, Ohio Society of Professional Engineers, 1975-.
Member, Columbus Rotary International, 1977-.

PROFESSIONAL ACTIVITIES (continued):

Member, Executive Board, ASEE Engineering College Council, 1979-.
Registered Professional Engineer, State of Ohio.
Member and currently chairman, Commission on Education for the Engineering Profession of the National Association of State Universities and Land-Grant Colleges (NASULGC), 1980-.

UNIVERSITY ACTIVITIES (abbreviated list):

Member, University Senate; past chairman and organizer of Faculty Caucus of OSU Senate, 1974-.
University Senate Committees:
  Academic Freedom and Responsibility.
  Chairman, Objective evaluation of Collective Bargaining Com.
  Honorary Degrees Committee.
Founded & Chaired Ohio Board of Regents' Energy Research Consortium.
Member, Council of Deans, 1976-
Represented Engineering interests to State Legislature & Congress.
Founded National Regulatory Research Institute, 1977.
Organized and launched $15K-fund drive for equipment and chairs, College of Engineering, 1978-.

SELECTED CIVIC ACTIVITIES:

Appointed by Governor James A. Rhodeas as a member of the Atomic Energy Advisory Board for the State of Ohio, 1970.
Session Chairman for the Columbus Chamber of Commerce Forum on Regional Growth, 1973.
Appointed to Mayor's Energy Advisory Panel, Columbus, 1975-.
Policy Advisor for the Ohio Public Utilities Commission, 1975-.
Energy Policy Advisor to Ohio Legislature, 1975-.
Provided technical counsel and background materials for candidates for governor (both parties), 1978.
Worked with Chamber of Commerce Committee to gain public approval for completion of the Columbus, Ohio freeway system, 1980.
Appointed member of the Ohio Industrial Technology and Enterprise Board, 1982-.
Member, 1983 Technology Roundtable of the Columbus Area Chamber of

STATEMENT OF DR. DONALD D. GLOWER, REPRESENTING THE ENGINEERING EDUCATION TASK FORCE, NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES; AMERICAN SOCIETY FOR ENGINEERING EDUCATION; ENGINEERING DEANS' COUNCIL; AND THE NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

Dr. GLOWER. Thank you, Mr. Chairman and members of the committee.

I am pleased to be with you this morning to discuss the engineering amendment to the National Science Foundation Organic Act.

I am Donald Glower, dean of the college of engineering from the Ohio State University. I am also chairman of the National Association of State Universities and Land-Grant Colleges—that's NASULGC, I guess. They have a Commission on Education for the Engineering Profession, and I chair that group.

However, today while representing that group, I am also here on behalf of the engineering education task force. This task force is a cooperative effort of NASULGC, the American Society for Engineering Education, the Council of Engineering Deans across the United States, and the National Society of Professional Engineers.

Mr. Chairman, our task force—that is, the chairman of our task force, Dr. Robert Kersten, appeared before your committee on February 29 to share his views. I would like to refer the committee to that testimony. It was a fine statement with which I concur fully. I believe it provides detailed background information on the views which I will express today.

Now I have submitted written testimony. I would propose, rather than read it, to hit some of the highlights.

Mr. **Fuqua**. Yes, Dr. Glower, we will, without objection, make your prepared statement part of the record, and if you wish to summarize, that will be permitted.

Dr. **Glower**. Fine.

I would like to point out that our task force and the organizations we represent are concerned about problems in two critical areas: Education and technological competitiveness. I'd like to point out that those two areas are very closely related.

Engineering education is important since our annual graduates make up approximately 10 percent of the engineering work force. These persons do the design, carry out the engineering tasks on a day-to-day basis, apply old and new technology toward product improvement, new product development, and so on, so that in fact over a 10-year span this group pretty much consists of all new faces. And I'm referring, Mr. Chairman and members of the committee, to those engineers who are in the frontline trenches using the technology that's available to them and doing the engineering work.

And as a consequence, each graduating class has a great impact upon the way engineering is done today. Our technological competitiveness in the international marketplace is vitally dependent upon these new graduates, upon their innovative and creative abilities, and upon the faculty whose responsibility it is to instill the concepts so important in the development of new technology and the transfer of today's state-of-the-art technology to the next generation of engineers, our students.

We want to emphasize that the engineering amendment of Congressmen Brown and Skeen, as we view it, the amendment to the NSF Organic Act, we'd like to view it not from the narrow science policy sphere; but instead we'd like to look at it in a broader viewpoint.

We feel that the amendment would clarify and establish the NSF role in maintaining technological leadership in this country. We feel that the NSF has the unique role of supporting basic research—academically based research including engineering research in a manner that has impact both on the research itself and on the talent, the students, and the faculty who are doing the research.

I would like to emphasize that the mission agencies are not focused on broad-based fundamental research. The intent of the mission support research is not to improve the quality and the content of education, as is the case for the NSF-sponsored research.

The NSF currently draws artificial distinctions between the type of research and the talent that is being educated and trained. I refer here to the research that the NSF is supposed to support as directed by the Organic Act.

The legislative history of the NSF, as was reported previously by my colleague, Mr. Kersten, indicates that support for engineering is permissive and not a part of the NSF mission.

Some say the amendment would benefit both science and engineering. We agree. We strongly feel that the amendment as it is now stated would pull the engineering and scientific community together, not push them farther apart.

The engineering initiatives now occurring in the NSF are very, very encouraging to us. We would point out that they are the result, however, of today's crisis in our international marketplace and, to no small degree, of the enthusiasm and the knowledge of this committee.

We think that the NSF should not be reacting to crisis situations. We point out, for example, that during the period of Sputnik there was great activity within the Foundation, more interest in engineering support, but that soon decayed. We would like to keep in mind this NSF history, and we would like to have steady and forceful support for engineering as we go into the future.

We feel that the demand for engineering research and talent will only grow with time. This year's NSF budget request now reflects a 22-percent increase for engineering, if that does indeed turn out to be real, we applaud the effort very much.

We would like to point out that we feel with this amendment the NSF could better accommodate growth through a long-range, long-run commitment to engineering. In closing, we would emphasize that the science side wins Nobel prizes; the engineering side wins world markets and will help us to keep our own domestic markets. We feel that both are needed and the NSF should be the lead agency in this respect.

I thank you, Mr. Chairman and members of the committee. I would be delighted to respond to questions if you have them.

[The prepared statement of Dr. Clower follows:]

Statement of

Dr. Donald D. Glower

Engineering Education Task Force

Mr. Chairman and Members of the Committee:

I am pleased to be with you this morning to discuss the engineering amendment to the National Science Foundation Organic Act. I am Dr. Donald D. Glower, Dean of Engineering at Ohio State University. I am also chairman of the National Association of State Universities and Land-Grant Colleges (NASULGC) Commission on Education for the Engineering Profession. Today, I am here on behalf of the Engineering Education Task Force, on which I represent NASULGC. This task force is a cooperative effort of NASULGC, the American Society for Engineering Education, including the Engineering Deans Council, and the National Society of Professional Engineers. Collectively, our membership consists of over 100,000 individual engineers from all disciplines and employment areas, over 100 corporate employers of engineers, and about 400 colleges and universities which enroll nearly one-half million engineering students in the United States.

The chairman of our task force, Dr. Robert D. Kersten, appeared before your Subcommittee on Science, Research and Technology on February 29 to share his views on institutional arrangements to support engineering. Before proceeding with my statement, I would like to refer the Committee to Dr. Kersten's fine statement, with which I concur fully. I believe it will provide detailed background information on the views I will express today.

Our task force and the organizations we represent are concernd about problems in two critical areas-engineering education and technological competitiveness. I would like to suggest that the Committee view this amendment not in the more narrow sphere of science policy, but from the broader perspective of innovation and industrial policy. Within that framework, we see these proposals as an extremely important contribution to the industrial competitiveness debate, and as an opportunity for this Committee to begin moving toward viable solutions. I would like to applaud Mr. Brown and Mr. Skeen for their fine leadership, and commend the Subcommittee on Science, Research and Technology for passing Mr. Skeen's HR 4822 substitute as an amendment to their NSF authorization bill.

By adding an engineering function to the NSF mission statement, the Committee would be reinforcing and strengthening the Foundation's ability to maintain and extend the nation's base of academic research and technical talent. This would help establish NSF as the lead agency within the Federal structure responsible for those essential ingredients of innovation and technological progress. The National Science Foundation should play this role. There is no other Federal agency which has the ability to support civilian, academically-based research in a manner that has an impact on BOTH the research and the talent. NSF has the unique ability to contribute to both the research and education needs of our increasingly technically dependent society. While the mission agencies can and do support engineering research, they do not support the very fundamental, broad-based research appropriate for NSF's program, and are not directed towards improving the quality of education as part of their research support. Mission agencies support mission-related research, while NSF supports basic and fundamental research of broad dimensions, in a manner that has a dramatic and positive influence over the quality of technical talent this country educates.

We believe the time has come to establish NSF as having a purpose broader than science. Currently, the Foundation's mission statement, enabling legislation and accompanying legislative history discourages this. Artificial distinctions are drawn between basic scientific research, which is the primary mission, and applied research, including that "which is normal for schools of engineering," which is to be supported at the Foundation's discretion. This definition of NSF's role implies that science and engineering research are of an entirely different nature, and that engineering research may not be "basic" enough to warrant NSF support. This definition was drafted in the 1960's--nearly two decades ago. It does not accurately characterize the situation in our research labs and colleges and universities today, where there is a very fuzzy line between basic science and fundamental engineering research. As Dr. Anna Harrison, AAAS President told the Subcommittee on Science, Research and Technology last month, distinctions between science and engineering research and talent are often blurred. The same research may be thought of as chemistry by a chemist, and engineering by a chemical engineer. Similary, research which I would think of as micro-electronics electrical engineering may appear to a physicist as solid state physics research on electronic properties. Yet, despite the similarities, there are important differences in the bodies of knowledge, data arrays and methodologies produced from science and engineering. Both are necessary ingredients for technological growth. While some people have said that amending NSF's mission statement to reflect a commitment to both areas would be divisive, we feel strongly that it would do just the opposite, further narrowing the gap between science and engineering. This amendment would enhance the ability of the Foundation to support academically-based research and talent, independent of the science or engineering label. This would clearly benefit both.

It can also be argued that statutory recognition is not necessary, since the Foundation is already moving in the direction of greater emphasis on engineering. Certainly, we applaud these engineering initiatives. In fact, we have long been supporters of programs to stimulate interdisciplinary, process-oriented research, and are extremely encouraged to see the Centers for Cross-disciplinary Research in the FY '85 budget request. However, we also recognize that these strides are the result of a very pro-engineering Science Advisor and NSF Director, as well as the work of this Committee. They come at a time when the need to improve our nation's engineering base is obvious. Similar moments have occured in the history of NSF. Immediately after Sputnik, funding for engineering activities rose, and after the crisis hype subsided, so did the commitment to engineering. As the world becomes more dependent on technology and our country's economic health becomes increasingly related to the competitiveness of our technology, the demand for quality engineering research and talent will only grow. The time has come to institutionalize our commitment to engineering.

We have also heard concern that extending the mission will result in zero-sum funding, with funds being taken out of science to go toward engineering. A quick glance at this year's NSF budget request shows that this simply is not the case. In response to well-documented needs for engineering support, the Engineering Directorate shows a 22% increase, compared to an overall increase of 16%. With this increase, engineering research would grow from 9.1% to 9.8% of the total NSF budget. One can hardly argue that the science directorates are being taken over by this

Administration's attention to engineering. The increases are all new, not reprogrammed money, which we feel must continue. We also believe, however, that while the growth in engineering is encouraging, the Foundation could better accommodate and emphasize the commitment if the mission statement and structure were modified, as proposed by Mr. Brown and Mr. Skeen.

In conclusion, I urge the Committee to help clarify the contribution the National Science Foundation can and is making to our technological competitiveness by adding an engineering function to its mission. While none of us are so naive to think that this alone will solve all our problems, we do believe it certainly is a very necessary and important step in the right direction. We all support science, but we must remember that while science wins Nobel prizes, it takes engineering to win markets. We need both!

Mr. Chairman, you and all your colleagues are to be commended for rasing this important topic. I would be pleased to answer any questions you might have, and will look forward to working with the Committee as your work progresses.

American Society for
Engineering Education
suite 200
eleven dupont circle, washington, d.c. 20036
(202) 293-7080

March 21, 1984

The Honorable Donald Fuqua
Committee on Science and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

On behalf of the Engineering Education Task Force, I respectfully request that the enclosed two (2) items be included as appendices to the testimony of Dr. Donald Glower, Dean of Engineering, Ohio State University, given before your Committee on March 21, 1984.

The items include 1) the text of a telegram from the Chairman of the Engineering Deans Council and 2) a compilation of letters from several deans of engineering.

Thank you very much.

With all best wishes, I am,

Very truly yours,

W E Lear

W. EDWARD LEAR
Executive Director

enclosures

FACSIMILE OF TELEGRAM DATED 3/20/84 FROM ENGINEERING DEANS COUNCIL
TO CHAIRMAN DONALD FUQUA
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

"THE ENGINEERING DEANS COUNCIL IS THE NATIONAL ORGANIZATION REPRESENTING OVER 200 CHIEF ADMINISTRATORS OF U.S. COLLEGES OF ENGINEERING WITH ACCREDITED ENGINEERING PROGRAMS. THE ENGINEERING DEANS COUNCIL FULLY SUPPORTS THE DEFINITION OF A CLEAR ENGINEERING MISSION FOR THE NATIONAL SCIENCE FOUNDATION THROUGH H.R. 4822.

"H.R. 4822 APPROPRIATELY ADDRESSES THE PROBLEM OF PROVIDING A STRONG SOURCE OF FEDERAL SUPPORT FOR FUNDAMENTAL ENGINEERING RESEARCH. THE ENGINEERING DEANS COUNCIL BELIEVES H.R. 4822 WILL STRENGTHEN THE ROLE OF NSF IN THE INNOVATION PROCESS, WHICH WOULD BENEFIT BOTH SCIENCE AND ENGINEERING; BUT MOST OF ALL THE ECONOMIC WELL-BEING OF OUR COUNTRY."

SINCERELY YOURS,

SIGNED:
ROBERT H. PAGE, CHAIRMAN
ENGINEERING DEANS COUNCIL
241 ZACHRY
ENGINEERING CENTER
TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77843

Appendix to testimony of Dr. Donald Glower, Dean of Engineering at Ohio State University, given on 3/21/84 before the House Science and Technology Committee.

SELECTED LETTERS FROM DEANS OF ENGINEERING SCHOOLS IN SUPPORT OF ENGINEERING MISSION STATEMENT IN CHARTER OF THE NATIONAL SCIENCE FOUNDATION

College of Engineering, University of Kentucky, Lexington, Kentucky,
Ray M. Bowen, Dean

Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire,
Carl F. Long, Dean

College of Engineering, University of Miami, Coral Gables, Florida,
Norman G. Einspruch, Dean

Bucknell University, Lewisburg, Pennsylvania, Barry R. Maxwell,
Dean of Engineering

School of Engineering, North Carolina State University, Raleigh, North Carolina,
Larry K. Monteith, Dean

College of Engineering and Physical Sciences, the University of Tulsa,
Tulsa, Oklahoma
N.D. Sylvester, Dean

College of Engineering and Physical Sciences, University of New Hampshire,
Durham, New Hampshire
Otis J. Sproul, Dean

March 21, 1984

Appendix to testimony of Dr. Donald Glower, Dean of Engineering at Ohio State University, given on 3/21/84 before the House Science and Technology Committee.

400

UNIVERSITY OF KENTUCKY
LEXINGTON, KENTUCKY 40506-0046

COLLEGE OF ENGINEERING
OFFICE OF THE DEAN

TELEPHONE: (606) 257-1687

March 8, 1984

Senator Wendell Ford
173A Russell
Washington, DC 20515

Dear Senator Ford:

The purpose of this letter is to call your attention to HB 4822, a bill to amend the National Science Foundation Act to include engineering function. This bill has been introduced by Representatives Brown and Skeen and has been referred to the House Science and Technology Committee. In September, 1983 I moved to Lexington to assume the position of Dean of Engineering at the University of Kentucky. For the previous twelve months I served at the National Science Foundation as Director of the Division of Mechanical Engineering and Applied Mechanics. I am writing you in my capacity as an engineering educator that is vitally concerned about the quality of engineering education in Kentucky and in the nation. Because of my experiance at NSF, I am convinced that the minor role played by engineering at NSF is a major contributor to the many problems faced by the academic engineering profession today. I could relate to you many examples, gained from my own experience at NSF, to support my view. You might be interested in the following information taken from the publication NSB 83-127, DISCUSSION ISSUES 1983, The Engineering Mission of NSF Over the Next Decade, Vol. 1. On page eighteen of this document it points out that there are approximately 3800 potential researchers within the Mechanical Engineering and Applied Mechanics disciplines. NSF was able to fund the research programs of approximately one out of every fifteen of these individuals. The situation in Mechanical Engineering and Applied Mechanics is typical of that in the entire Engineering Directorate at NSF. In some of the science disciplines funding is available for approximately one out of every three researchers. If one understands that NSF is the primary source of research funds for young faculty members, it is really not surprising that many young engineering researchers are choosing not to enter the academic profession. The College of Engineering at the University of Kentucky is blessed with a strong faculty dedicated to excellent teaching, research and service to Kentucky. It is our every intention to become stronger. HR 4822 is important to our future development. If this reaches the Senate, I hope you will give it your strongest support.

At a time in our nation's history where we are undergoing a major technological revolution, we need more of our best young minds to teach the engineers of the future. HR 4822 is an important step towards recognizing the important of academic engineering research to the health of the nation.

Sincerely,

Ray M. Bowen
Ray M. Bowen
Dean

RMB:jbb

THAYER SCHOOL OF ENGINEERING
DARTMOUTH COLLEGE • HANOVER • NEW HAMPSHIRE 03755
TEL. (603) 646-2238

CARL F. LONG
Dean

February 27, 1984

The Honorable Judd Gregg
308 Cannon HOB
Washington, D.C. 20515

Dear Representative Gregg:

I am writing to urge your co-sponsorship of HR 4822, a bill that proposes inclusion of an engineering function in the National Science Foundation, and which also would display the importance of both science and engineering to our Nation's future and the well-being of its people.

I am obviously pleased with the increased funding in the Engineering Directorate which is needed and important in maintaining the viability of our engineering faculty and graduate degree programs. But I believe that HR 4822 is of even greater importance in that it couples engineering and science as co-equals.

Much discussion is presently being generated on the distinctions between science, applied science, and engineering research. I will avoid contributing to that discussion, for the present; the issue will be clarified if NSF becomes the National Science and Engineering Foundation. I would comment that there have been many expressions of concern that engineering education is often overbalanced and that too often our inability to interact with industry is due to our concentration on pure research. Since graduate education and research are prime attractors of young Ph.D.'s into academe, and since both are greatly dependent upon federal funding, the nature of research funded will shape the interests of these faculty, and they in turn will shape the education of engineers both at the graduate and undergraduate level. The past and present emphasis of NSF on the purer research has shaped today's engineering schools. The legislation in HR 4822 will ultimately broaden the focus of NSF and the nature of engineering education.

I hope you will lend HR 4822 your support.

Very truly yours,

CFL

Carl F. Long

CFL:ap

bcc: Kathi Ann Brown
ASEE

University of Miami
Coral Gables, Florida 33124
COLLEGE OF ENGINEERING
P.O. Box 248294 (305) 284-2404

February 23, 1984

Congressman Thomas F. Lewis
1313 Longworth HOB
Washington, D.C. 20515

Dear Congressman Lewis:

This is to bring to your attention H.R. 4822, a bill to amend the National Science Foundation Act to include engineering. As you are aware, engineering is the backbone of our nation's industrial enterprise. To ensure appropriate attention to engineering research as it complements scientific research, it is proposed that the NSF intensify its activities in the engineering field.

For several years, I have counseled my colleagues that it would be debilitating to establish an engineering foundation whose work parallels that of the NSF; expanding the NSF charter would lead to a much more effective use of resources. I urge your full and proper consideration of H.R. 4822, which offers promise of satisfying clearly perceived and urgent national needs.

Please do not hesitate to call on me for clarification or guidance on this important issue.

Best wishes.

Very truly yours,

Norman G. Einspruch
Dean

NGE:rl

BUCKNELL

Office of the
Dean of Engineering

Bucknell University
Lewisburg, Pennsylvania 17837
Phone (717) 524-3711

COPY

March 1, 1984

Representative George W. Gekas
1008 Longworth HOB
Washington, DC 20515

Dear George;

As one of your constituents and Dean of the College of Engineering at Bucknell, I write to urge your support and possible co-sponsorship of H.R. 4822, a bill to provide an expanded and more secure home for engineering within the National Science Foundation.

As I understand it, this bill was introduced in the House on February 9, 1984, by Representatives Brown and Skeen. The bill addresses the problem of providing a strong source of Federal support for fundamental engineering research through expansion of engineering's roll in the National Science Foundation. The bill would achieve this by changing NSF's enabling legislation to permit a more defined partnership between science and engineering. In my view this would be attained without impinging on the established science mission of the NSF. Science and engineering are interlinked and not competitive, and this bill would assure the continued productive alliance enjoyed by both.

Unfortunately, there is often misunderstanding about engineering's partnership with science, particularly as it relates to the value of fundamental engineering research. Too often, engineering research is mistakenly lumped under the term "applied research", research for specific commercial use by industry. Although this is occasionally the fact, much of the research done in engineering institutions, including Bucknell's, is of a basic or general nature, and does not receive support from industry. Thus, we look to the National Science Foundation as an appropriate funding source for much of the basic research conducted in engineering institutions.

In closing, let me applaud the National Science Foundation's recent initiatives for engineering. Clearly, they are needed and much appreciated. However, H.R. 4822 will help assure that such improvements will become a permanent part of NSF's mission. If you have any questions regarding my views on this matter, please feel free to contact me.

Sincerely,

Barry R. Maxwell
Dean of Engineering

BRM:dgs

North Carolina State University
School of Engineering

Office of the Dean

Box 7901
Raleigh, N.C. 27695-7901

1984 MAR 12 PM 2:36

March 8, 1984

The Honorable Ike Andrews
U.S. House of Representatives
2201 Rayburn HOB
Washington, D.C. 20515

Dear Representative Andrews:

I wish to strongly urge you to support H.R. 4822, a bill to amend the National Science Foundation Act of 1950 to include the engineering function. The time has arrived when engineering must be recognized more formally in our national research support structure. In particular, I view H.R. 4822 as the logical culmination of a progression of improved recognition for engineering within the National Science Foundation. During the ten-year period, engineering in the NSF has emerged from division status to part of a directorate, and then to its present position as a separate directorate. Engineering can no longer be regarded as one of the sciences or simply the application of science, but rather an enterprise with distinctive characteristics and academic aspects of its own.

In addition, I want to voice support of fundamental engineering research as a distinct intellectual activity apart from scientific exploration and industry application. In today's complex technological world, it is overly simplistic to classify research as either basic or applied. In fact, fundamental engineering research has always been present as a realm of research inquiry, but it has traditionally been overlooked by both the federal government and industry. However, the competitive and rapidly changing world of technological development has brought increased emphasis on the importance of fundamental engineering research, and this focus will likely remain throughout the period now popularly identified as the second industrial revolution. I have attached a description of a precision engineering program underway in the Mechanical and Aerospace Engineering Department at North Carolina State University. I believe this serves as a very excellent example of fundamental engineering research.

In conclusion, I believe H.R. 4822 will strengthen the role of engineering in the innovation process, which will benefit both science and engineering as well as the economic well-being of the United States.

Sincerely,

Larry Monteith

Larry K. Monteith
Dean of Engineering

Attachment

North Carolina State University is North Carolina's original land-grant institution
and a constituent institution of The University of North Carolina

Fundamental Engineering Research
In
Precision Engineering

The Precision Engineering Program at North Carolina State University involves the study of new methods for automatic control of precision manufacturing processes. Automatic control means that the process should monitor itself and correct the part or process during fabrication to achieve the desired accuracy. The emphasis is on the production of parts which require dimensional control on the order of 10 millionths of an inch. Examples of components requiring such accuracy are optical devices, VSLI circuits, and precision bearings and gears.

The Precision Engineering Program is basic research with an objective quite different from an applied research or development program. Rather than attempting to find a specific design to achieve the goal, the research is aimed at studying the limits of current technology and inventing new techniques to increase the precision of the final part. Questions to be addressed include how to identify and measure potentially bad parts, what changes in the process are required to keep these parts within tolerance, and how to effect these changes. The speed and accuracy requirements will push the current state-of-the-art of sensor, computer, and actuator design and require basic research in hardware and software to find new approaches. The goal is to create the foundation for a new production process which will produce super-precision parts automatically.

Letter from: The University of Tulsa (Oklahoma)
College of Engineering and Physical Sciences
Office of the Dean

February 27, 1984

The Honorable James R. Jones
203 Cannon
Washington, DC 20515

Dear Jim:

I am writing to urge you to cosponsor H.R. 4822, a bill to provide an expanded and more secure home for engineering within the National Science Foundation. Too often perceived as a subset of scientific endeavor, engineering has only recently begun to be understood and valued as a separate, but complementary, component in the challenge to harness our planet's resources for social and economic benefit. The strength and vitality of both science and engineering are requisite if the United States is to retain its technological world leadership in these increasingly competitive times.

H.R. 4822 addresses the problem of providing a strong source of Federal support for fundamental engineering research through expansion of engineering's role in the National Science Foundation. The proposal achieves this through changes to NSF's enabling legislation to allow for a defined and enhanced partnership between science and engineering. That this is also attained without impinging on the established science mission of the National Science Foundation is an astute recognition of the interlinked—not competitive—relationship of engineering to the sciences. This understanding is fundamental to the continued productive alliance enjoyed by both.

Hand-in-hand with the misunderstanding about engineering's partnership with science seems to go a misinterpretation of the value of fundamental engineering research. Unfortunately, too often all engineering research which is done by universities is lumped mistakenly under the term "applied research," research for specific commercial use done in industry. Substantially generic in nature, universities' fundamental research does not garner long-term industry support, yet is vital to technological breakthroughs.

This expertise, however, cannot be attained if our engineering universities and colleges continue to suffer from shortages of qualified faculty, by phenomenal student enrollments that strain understaffed programs to the breaking point, and by an ever-deteriorating lack of precision laboratory equipment. We cannot hope to make real progress in the research that will advance us as a technological leader unless we keep our engineering community strong. We look to the National Science Foundation as an appropriate medium for providing much-needed support through engineering scholarships, instrumentation grants, and other methods.

In closing, let me applaud the National Science Foundation's recently unveiled initiatives for engineering. They are needed and timely. However, H.R. 4822 will assure the nation that such improvements will become a permanent part of the Foundation's mission. Science, engineering and our entire society can only benefit.

Very truly yours,

N. D. Sylvester
Dean

1C9/SN84058.4

Letter from: University of New Hampshire
College of Engineering and Physical Sciences
Office of the Dean

March 15, 1984

The Honorable Judd Gregg
308 Cannon HOB
Washington, D.C. 20515

Dear Representative Gregg:

I am writing to urge you to cosponsor HR4822, a bill to provide an expanded and more secure home for engineering in the National Science Foundation.

Engineering has only recently been perceived as a discipline distinct from science, yet it is the basis for our industrial productive capacity and social well being. We must increase the strength of our engineering research base, as well as that of science, if we are to retain our technological leadership in the world.

HR4822 would provide a strong base for Federal support of fundamental engineering research through an expansion of engineering's role in the National Science Foundation. The bill would change NSF's enabling legislation to provide a defined and enhanced partnership between engineering and science without decreasing the NSF support for science.

A misunderstanding of the nature of fundamental engineering research often results in people thinking of it as "applied research." Let me cite one example of work at the University of New Hampshire for which we are attempting to attract Foundation support. The robotics group in our Electrical and Computer Engineering Department is working on a third generation robot. They are marrying a television camera, which provides artificial intelligence for the robot, to a computer which interprets the picture and which in turn directs the robot to perform its function. Providing intelligence to a robot, while not done currently in industry, is necessary since assembly lines rarely present the part to be operated on in the same place every time. This work would allow the robot "to see." The results from this proposed research would have direct benefit to New Hampshire's industrial economy since, in many parts of our state, the available work force does not meet the demand. More intelligent robots would increase our industrial productivity. I have many other examples at the University of New Hampshire which I could cite.

The need for an enhanced engineering role at NSF is pressing and it is large. The NSF is the appropriate medium for providing much needed support of engineering research, student scholarships and equipment grants.

The recent increased emphasis for engineering within the National Science Foundation is a good start. HR4822 will assure that these recent initiatives become permanent. I would be pleased to provide further information and assistance to you on this subject.

Sincerely,

Otis J. Sproul
Dean

OJS/bl

Mr. **Fuqua**. Thank you very much, Dr. Glower.

You were here, I think, when Dr. Press testified and indicated that there were some, I think, $786 million, approximately, of other agencies that fund research, and I asked the question, "How much of that went to colleges and universities really for basic, fundamental work in engineering?" As a dean of engineering, are you familiar with how much of those figures from other than NSF go to colleges and universities for the more fundamental engineering research?

Dr. **Glower**. Mr. Chairman, I could not give you a specific number on that, but I am very familiar with the type of research that is done from the mission agencies, since my university and my college of engineering has a very large research program with many of the other agencies.

I would emphasize that all of these are very sharply focused. The research is sold on the basis of doing a very specific job for the mission agency itself. Very little of that is pointed toward what we would consider basic research.

Mr. **Fuqua**. I think you summed it up very well in your prepared statement on page 2, and if I could just quote that fact down at the bottom of the page. It says:

> While the mission agencies can and do support engineering research, they do not support the very fundamental, broad-based research appropriate for NSF programs and are not directed toward improving the quality of education as part of their research effort.

I think it comes back to the point that I've tried to make repeatedly, not only in engineering but in other disciplines, that it's in our colleges and universities where we train the people. That is the training ground for the future scientists and engineers. And if we lessen our support or have less than a strong commitment, maybe I should say, then we're failing at a very fundamental part of where we're coming from and where we get the fine people that graduate from your college and others throughout the country, regardless of what discipline it is.

And if it's a very narrow focus and not dealing with the broad-based part, then we're defeating the long-range goals of this country, in my opinion.

Dr. **Glower**. Yes, sir, we agree 100 percent with that. Our mission at the university, and in particular in the engineering area, is to educate tomorrow's generation—that's today's students—tomorrow's generation of professionals who will be on the frontlines developing and applying the technology. It's important that we educate our youngsters in the state of the art of the particular profession, otherwise, our graduating youngsters are out of date when they leave the university.

Mr. **Fuqua**. And this is where the Government, as well as industry, gets the engineers and researchers to carry on very important work for them. They utilize the training that they receive in the colleges and universities, but they're not really the training ground. The training ground is back at the colleges and universities.

You've heard the question this morning, that if we change the Organic Act, there will be a significant increase in support for engineering at the expense of science and I would like to get your answer. And I know that Dr. Kersten addressed that when he testified before the committee, but maybe you would like to elaborate on that. I know you touched on it briefly in your statement, but maybe you'd like to elaborate on that.

Dr. **Glower**. Yes, I would be delighted to.

Let me emphasize that this task force has come forth in support of this Brown-Skeen amendment, and this is one of the first things that the engineering deans across the country have agreed almost unanimously on. At our various meetings there has been great debate on this point. It has always been mentioned, it has been argued, that we are interested in a partnership with science, a fair partnership. We are not interested in a different way of cutting up the pie, so to speak. We are not interested in a zero-sum game. I think we can give you very strong assurance on that.

We are interested in being partners with science and making this a closer partnership.

Mr. **Fuqua**. I see that Dr. Tribus has arrived. We'll be pleased to hear from you at this time, and then we'll resume the questioning with the two of you when you conclude.

[A biographic sketch of Dr. Tribus follows:]

Biographical Sketch of Dr. Myron Tribus

Dr. Myron Tribus is currently Director, Center for Advanced Engineering Study, Massachusetts Institute of Technology. He was formerly Vice President for Research and Engineering at Xerox, where he was responsible for the R.D.&.E. of the entire line of copiers, duplicators, and telecopiers. Before that he served for two years as Assistant Secretary for Science and Technology in the Department of Commerce. He was for eight years Dean of the Thayer School of Engineering at Dartmouth College.

Dr. Tribus has published over 100 papers on topics ranging from academic topics such as heat transfer, thermodynamics, probability, decision theory, and fluid mechanics to applied topics such as aircraft de-icing, air conditioning, sea water demineralization, reliability engineering and design. He has also published and lectured on technology in public policy, engineering education for public service, and the position of U.S. Technology in world trade.

Dr. Tribus is a member of the National Academy of Engineering. He has served on several boards of directors and has been consultant to many corporations and agencies of government. He is on the Board of the Technion, Haifa, Israel.

Dr. Tribus holds the PhD from UCLA, has received two honorary doctorates and five awards for technical papers and public service. He is married and has two daughters.

STATEMENT OF DR. MYRON TRIBUS, REPRESENTING THE NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

Dr. **Tribus**. Thank you, Mr. Chairman.

Mr. **Fuqua**. I might mention, as I did to Dr. Glower, that if you wish to make your statement—submit it for the record and summarize, that would be——

Dr. **Tribus**. Well, I intend to do that.

Mr. **Brown**. It would be better if he read it, Mr. Chairman. It's short and he talks a long time. [Laughter.]

Dr. **Tribus**. I'm known to Congressman Brown, I see.

Well, it is a very short statement.

I'm Myron Tribus, director of the Center for Advanced Engineering Study at MIT. I've been an executive in industry, serving for 4 years as a senior vice president for research and engineering at Xerox. I've been the assistant secretary of commerce for science and technology. For 8 years I was dean of the Thayer School of Engineering at Dartmouth. I've been a professor of engineering. I've worked as an engineer in industry with General Electric and other companies. I've served as a design and development officer in the Air Force as a captain. As you can see from the record, I have trouble holding a job.

I'm a member of the National Academy of Engineering and of the National Society of Professional Engineers, whom I represent today. And my views do not necessarily represent the views of MIT.

I serve as the chairman of the NSPE technology policy task force, which has been working to define the problems and seek solutions to our Nation's lagging technological competitiveness. In this capacity, I've become well acquainted with the menu of industrial policy proposals pending before the Congress, and I'd like to address the amendment we're discussing today from that perspective.

I came here this morning from an appearance before your colleagues on the Banking Committee to comment on their proposal to establish an Advanced Research Foundation. I have also spent a good deal of time examining Mr. Brown's bill to create a National Technology Foundation, and I've looked at the Democratic caucus' plan for an Economic Cooperation Council as well.

Now there are pros and cons associated with these initiatives, as I'm sure you know, and I've commented extensively in that regard. But independent of the absolute or potential merit of the proposals, I believe many of their objectives can be accomplished under existing structures and statutes.

While some of the existing vehicles may require significant modification to have a maximum impact on our competitiveness, others can be improved with relatively minor changes.

So, in this vein, I suggest that the National Science Foundation has an important role in maintaining our Nation's technological leadership, and amending the act by adding an engineering research and education function to the mission statement would help clarify and emphasize this role. A commitment to fundamental engineering research and education is essential to establish NSF's responsibility for research and talent in both science and engineering.

Our technological competitiveness depends on the quality of engineering research and talent. We need both the talent and the research. Without them, the private sector wouldn't have the tools necessary to develop commercial applications. Excellence in science is necessary but it's not enough. The National Science Foundation cannot leave—cannot afford to leave support for fundamental engineering research and education to the discretion just of industry.

I urge your committees to follow your colleagues on the Science—on the other subcommittee—by supporting the amendment, and I'd like to congratulate Mr. Brown and Mr. Skeen for their leadership on this issue.

In short, I support what you fellows want to do. I should have said that and stopped.

[The prepared statement of Dr. Tribus follows:]

STATEMENT OF

DR. MYRON TRIBUS, P.E.

Good morning, Mr. Chairman, Members of the Committee.

I am Myron Tribus, Director of the Center for Advanced Engineering Study at MIT. I have been an executive in industry, serving four years as Senior Vice President for Research and Engineering at the Xerox Corporation. I have served as Assistant Secretary of Commerce for Science and Technology. For eight years I was Dean of the Thayer School of Engineering at Dartmouth College. Before that I was a Professor of Engineering at UCLA. I have worked as an engineer in industry and served as a Design and Development Officer in the Air Force as a Captain. I am a member of the National Academy of Engineering and of the National Society of Professional Engineers (NSPE), whom I represent today. My views do not necessarily represent the views of MIT.

I serve as the Chairman of NSPE's Technology Policy Task Force, which has been working to define the problems and seek solutions to our nation's lagging technological competitiveness. In this capacity and through my many other endeavors, I have become well acquainted with the menu of industrial policy proposals pending before Congress. I would like to address the amendment we are discussing today from that perspective.

Earlier this morning, I appeared before your colleagues on the Banking Committee to comment on their proposal to establish an Advanced Research Foundation. I have also spent a great deal of time examining Mr. Brown's bill to create a National Technology Foundation, and have looked closely at the Democratic Caucus' plan for an Economic Cooperation Council as well. There are both pros and cons associated with these initiatives, and as many of you know, I have commented extensively in that regard. But independent of the absolute or potential merit of the proposals, I believe many of their objectives can be accomplished under existing structures and statutes. While some of the existing vehicles may require siginificant modification to have a maximum impact on our competitiveness, others can be improved with relatively minor changes. I believe we should attempt to optimize the contributions that can be made with the structures and statutes already in place, while continuing to examine and debate new alternatives.

In this vein, I suggest that the National Science Foundation has an extremely important role in maintaining our nation's technological leadership. Amending the Organic Act by adding on an engineering research and education function to the mission statement helps clarify and emphasize this role. A commitment to fundamental engineering research and education is essential to establish NSF's responsibility for research and talent in both science and engineering.

There is no doubt that our technological competitiveness is inextricably tied to the quality of our engineering research and talent. Without these two critical resources, the private sector would not have the tools necessary to conduct the commerical development which results in new or improved products and services. While excellence in science is clearly necessary, it is not sufficient if we are to maintain and extend our technological leadership. The National Science Foundation cannot afford to leave support for fundamental engineering research and education at the discretion of the prevailing powers.

I urge the Committee to follow your colleagues on the SRT Subcommittee by supporting the amendment, and would like to congratulate Mr. Brown and Mr. Skeen for their excellent leadership on this issue. I would be pleased to answer any questions you might have.

Mr. **Fuqua**. Thank you. Thank you very much.

Dr. Tribus, what are your thoughts about some new thrust in engineering and applied research in some of the other Federal agencies, the other more mission-oriented agencies?

Dr. **Tribus**. Well, a mission-oriented agency will pursue a problem for its own objective, not just to enhance the competitiveness of the U.S. I think it will take a much too narrow view of what needs to be done. This is why I have said this is a good thing to do, but it's not enough.

First, it's a good thing to do because there are areas of technology where you just can't get support because they're so broad and across the board, nobody wants to support it. I'll give you a specific example.

There was NSF support given to me a number of years ago in the field that I called thermoeconomics. I had a lot of trouble getting support for that work. Unknown to me, there was at the time a fellow in the Soviet Union who was reading the report generated through my research. This research has to do with improving methods of design in engineering. It isn't fundamental science, but it's fundamental to carrying out engineering.

That work was studied by this fellow, and he happens to have left the Soviet Union and is now a citizen of the United States. And based on that work and based on that technique of thinking about things in engineering, he was able to come up with an idea, and this is his statement to me because he came to see me, the fellow whose work he studied from such a long distance and whom he'd never met, to explain that that was crucial to his development of a new form of power system which promises a significant advance in the fuel economy of powerplants, a very significant advance.

Now I just point out that the struggles I went through to get support for that—I couldn't get it from any mission-oriented agency because it was fundamental to just doing engineering, see. And it wasn't science, and it was only due to the very, very fine intercession of a scientist friend of mine who went before the NSF and said, "Well, I think Tribus deserves support for this just because he's earned it in the past," and that was the only basis on which I got it because it didn't hold up as good science.

So that's just an example of why, one, I say NSF has to be in the business; and, two, that NSF in that business won't be enough. The mission-oriented agencies won't support that sort of thing, and NSF, if properly directed, will. But that won't be enough because we need also to pay attention to the larger issues that don't involve advanced scientific research, but involve preparing our labor force to deal with the advances in research.

For example, we have—right now we have a very important mission in the country to improve quality and productivity. Those of us that are working in this field intensively recognize that there is an enormous gap between the education of our work force and what is required to do that. Who's going to worry about that? It's going to take something beyond NSF.

So, on the one hand, I'm promoting this change in NSF because I think it's a good thing, particularly in the support of certain kinds of technology, and I also am speaking very strongly for the development of another agency to look at those broader issues. And I would say—and I know this conflicts with testimony you heard before—that mission-oriented agencies support is not enough because they don't look—they only look very narrowly at what they're trying to do and not at the peripheral things, and certainly not at the whole question of U.S. competitiveness. They're going to focus just on how to get whatever it is that they want most quickly, and particularly at budget time they have to justify that what they're doing is very narrowly focused on what they're supposed to do.

When I was here in Washington, I learned my lesson—it's a Government of laws, not of men. And I did not have the opportunity to do what I thought ought to be done, but rather I had to stay very close to the law.

Mr. **Fuqua**. Thank you.

Mr. Brown.

Mr. **Brown**. I appreciate the testimony of both of the panelists here.

I might say to Dr. Glower that it was Dr. Kersten's testimony that led me to feel that this was a desirable approach to take with the National Science Foundation, and I want to commend him and you, representing the engineering education task force, for persevering in this.

Having said this, I'm also concerned about Dr. Tribus' statement that this is not necessarily a comprehensive solution to the problems of innovation and productivity that we face, and I continue to be concerned with that problem and what can be done about it. I'm not sure that we have yet settled on a mode of development here which will address this problem.

The committee that you spoke to earlier, Dr. Tribus, I presume is concerned with that problem, as we are here.

At one point a few months ago there seemed to be developing, in connection with the reorganization of the Department of Commerce, a move toward establishing an innovation and productivity administration within that trade department. I don't recall the exact setup that was proposed, but at least it seemed to recognize the need to do something here.

I have felt—and I will ask you to comment on it—that just as we are here seeking fundamentally to kind of focus NSF's attention on this problem of fundamental engineering, that perhaps through improving the quality of what we're already doing in some other things, maybe by reorganizing some other existing agencies into a more effective and focused effort, we might be able to do a better job on addressing this innovation and productivity issue. And I'd like to ask you to comment a little bit further on what your thinking has been, or the current status of your thinking, with regard to that problem.

As you have commented, we have before us a menu of other proposals, and I'm, in my own thinking, not quite clear what to do with them at this point.

Dr. **Tribus**. Well, the difficulty I face in giving you a good answer, a succinct answer, to that is that any solution that is put forward has not only to meet the problem, but be politically viable, and I don't know enough about that side of things.

Mr. **Brown**. That's been my problem.

Dr. TRIBUS. Yes.

I think it's important that we at least get agreement on, first, what we ought to be doing and what is appropriate for Government to do, and then, finally, how to organize the Government to do it. And I would say a few words about each of those.

The problem that drives us all is not education of engineers for the sake of having more engineers or for the cultural value, but because we see it as an important ingredient in international competition. We have lots of evidence that we're falling behind in international competition. In the commercial world we have trouble keeping up in our own marketplace. Other countries send products and steal our markets and close down our industries and cause unemployment, and that is the big motivator for the whole thing. We've got to keep that in mind.

That means we have to look at these discussions about NSF as a small part of a much bigger problem. Now the main reasons, the main things that are required for us to compete successfully in our own markets and internationally I put under four categories: invention, coming up with new ideas; innovation, reducing those ideas to practice, organizing people and machinery and all the other things required to do it; then doing it with high quality. After you've decided to do it, do it very well; and then achieve high productivity, low cost. They have to do all of those things.

Doing all those things is the business of the private sector. The business of the Government is to provide the infrastructure which makes those things possible.

Now we keep focusing on invention, and we have focused for a long time on invention. The result of that is that we are probably one of the most inventive nations in the world. All kinds of inventions come out of the United States, and have been for a long time.

The rate at which we innovate, the rate at which we turn those inventions into actual products and services, has been decreasing. We are losing to the Japanese who have have turned out to be extraordinarily good innovators.

Last Saturday I spent with Dr. Yoshikazu Tsuda, who is one of the leading educators in Japan. He has traveled all over the world, and he said to me, "You go to a research and development organization in the United States and they are emphasizing invention. You go to a similar organization in Japan and they are emphasizing innovation."

And so we invent the liquid crystal display, and the Japanese make 90 percent of them. We invent the video tape recorder, and they market them. We invent the laser disk, and they're strong in the field. We invent the personal computer, and they're about to invade us with that.

So we've got to keep clear that it's more than just invention; it's innovation. We have to understand what the role of Government is in promoting innovation, but beyond that, quality. You cannot produce high quality products with a work force that's not well educated, and Government has a big role to play in education, but again education is a State level activity but the Government has a leadership position that it can play.

And, finally, there is productivity, and that also leads us to the whole issue of who supports general manufacturing technology and who sees that there is a balance in the education of our engineering work force and the capabilities required in industry.

A few years ago I would have had great difficulty getting NSF support for certain kinds of problems that I see occurring in industry today. Today manufacturing is a little more accepted, and NSF is more likely to give support to it, but nowhere near the kind of support that's ultimately required in this field.

So when I look at all four of those, I say what I want to see, first of all, is an agency of the Government that is gathering the data and sifting through it and understanding what is happening to us in all four of those elements, not just one. There isn't any such agency in the Government today. You've got to know what's going on.

Second, because, for a variety of reasons that I don't have to defend to anybody of any political party, the primary responsibility for making it happen is in the private sector. Government is not the innovator. Government is not the producer. Government is not the agency to make sure that it's high quality.

That means that we have to find different ways for this agency that will gather the facts, that will know a lot, to interact with the important players, and we have to identify who they are.

I led a task force for the NSPE last year, and we produced a report in which, having analyzed this situation, we concluded that the practices and procedures of the Federal Government today are inappropriate to this class of problem.

I'm only saying, in other words, what John Kemeny said after he got through the Kemeny Commission experience. He sat down and wrote several very thoughtful articles saying that the practices and procedures of Government today are inappropriate to the problems posed by technology, and particularly the advance of technology, and the way they impinge on our social structure and the way they impinge on our health and safety.

So now I would like to see an agency that went beyond what is being said for the NSF, and I don't care whether NSF continues to do this or not, because what I'm talking about goes way beyond NSF, an agency that is gathering the data, interacting with the important players, which must include labor, because what we're talking about is the preservation of jobs and preservation of our position in the world.

We need an agency that has the knowledge and the practices and procedures to interact with the important players, the important stakeholders, and come up with programs and proposals which do not take away from the private sector, do not impinge on the private sector's opportunities for initiative, but will help where critical areas are found. Let me give you a specific example, and I think this is something that's being copied in the United States under the leadership of Bill Norris, of Control Data, when he formed a consortium of companies.

When the Japanese decided they wanted to go after the advanced chip, they formed a laboratory under the general aegis of MITI, but people from industry came to that laboratory. I think some 22 companies were involved, and they sent people who worked in the laboratory as a team solving the important technological problems. And when they reached a point where they saw that they had the technology well enough advanced, they all went back to their own companies; the laboratory was disbanded; and that technology was advanced and diffused amongst the players.

Now that kind of thing may be necessary in the future in some areas, and I don't have answers because the questions are all so different. But what I do see is a process that we can put in place, and we need an organization with leadership to carry out that process.

I'm afraid I gave you just one more data point, Mr. Brown, on my tendency to talk too long, but it was a tough question.

Mr. BROWN. Well, you have very well laid out the way I've been thinking about this problem. As you've indicated, I don't see at this point a solution to it, but until we all come to better understand what we're trying to do, I don't think we'll get a solution. And you've made, of course, a great contribution to that.

I don't want to belabor this, but, Dr. Glower, do you have any comments on——

Dr. GLOWER. Yes, Congressman, I would like to make a comment.

I think that, reflecting on the debates that the deans have had at the various forums, they do argue over forward-looking topics, such as Dr. Tribus has indicated, and I would say we could support everything that he has said.

However, I guess I would also want to emphasize that the deans are strongly in support of the Brown-Skeen amendment, and we would be very disappointed if that did not get passed.

We would like to see something happen now. And when we look toward a new agency or a new complicated or complex organization, that is a long time into the future. We're having difficulty right now. In engineering education we're having great difficulty. We would like to find some relief soon.

Mr. BROWN. You at least see this as a morale booster until we can do something more concrete, then?

Dr. GLOWER. Yes, sir.

Dr. TRIBUS. I'd like to support that. As we know, the best is the enemy of the good. And this is an important step to be taken now and pushed hard now, and I tried in my testimony to make the point that there were other things to be done. We don't have to wait for them. This step is necessary but not sufficient. We ought to get forward with it.

Mr. BROWN. Thank you, very much.

Mr. FUQUA. Thank you, very much, Dr. Glower. We appreciate your being here and your testimony.

Dr. Tribus, we thank you very much for your contributions this morning. I'm glad to see somebody that has some enthusiasm about something they believe in.

Our next witness is Dr. Richard S. Nicholson, the Acting Deputy Director of the National Science Foundation.

[A biographical sketch of Dr. Nicholson follows:]

RESUME

Richard S. Nicholson

Personal Data

Birthplace : Des Moines, Iowa
Birthdate : April 5, 1938
Marital Status : Married
Military Status: Honorable Discharge, USNR, May 9, 1963

Education

BS in chemistry, Iowa State University, Ames, Iowa, 1960
PhD in chemistry, University of Wisconsin, Madison, Wisconsin, 1964.

Positions Held

Staff Director, National Science Foundation, 1983-Present
Acting Deputy Director, National Science Foundation, 1983-present.
Executive Director, National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1982-1983
Director, Chemistry Division, National Science Foundation, 1977-1982.
Deputy Assistant Director for the Mathematical and Physical Sciences, National Science Foundation, 1980-1982.
Director, Division of Information Systems, National Science Foundation, 1979-1980.
Senior Planning Officer for the Mathematical and Physical Sciences, National Science Foundation, 1978-1979.
Special Assistant to the Director of the National Science Foundation, 1976-1977.
Deputy Director, Chemistry Division, National Science Foundation, 1975-1976.
Director, Chemical Instrumentation Program, Chemistry Division, National Science Foundation, 1971-1975.
Director, Chemical Analysis Program, Chemistry Division, National Science Foundation, 1970-1971.
Associate Professor of Chemistry, Michigan State University, 1967-1970.
Assistant Professor of Chemistry, Michigan State University, 1964-1967.
Postdoctoral Research Associate, University of Wisconsin, 1963-1964.

Professional Activities and Honors

Dow Fellow (1962-1963); National Science Foundation Fellow (1961-1962); Eastman Kodak Scientific Award (1964, $1,000); National Councilor for Michigan State University Section, American Chemical Society (1965-1968); Chairman, Michigan State University Section, American Chemical Society (1968-1970); Phi Eta Sigma (1968); Sigma Xi, (1965); American Chemical Society; American Association for the Advancement of Science; Chairman, Symposium on Bioelectrochemistry (1975); member, Bioelectrochemistry Liaison Committee of the Electrochemistry Society (1975); member, National Meetings Program Committee of the American Chemical Society, Division of Education (1975); William A. Jump Meritorious Award for Exemplary

Achievement in Public Administration (1975); Executive Development Program (1975); Executive Secretary, The President's Committee on the National Medal of Science (1976-to present); Representative Federal Council on Arts and Humanities (1976-1977); Nominations Committee, Chemical Society of Washington (1977); Member, Office of Science and Technology Policy's Working Group on Basic Research in the Department of Energy (1978); The NSF's Meritorious Service Award (1978, the Agency's second highest honor); Consultant, Office of Science and Technology Policy, President's Message to Congress on Science and Technology (1979); The NSF's Superior Accomplishment Award (1979, $1,000 "for work on the Master Grant Project"); Consultant to Office on Science and Technology Policy for President's Message on Industrial Innovation (1979); Office of Science and Technology Policy Advisory Panel on the Cooperative Automative Research Program (1979); Fellow of the American Association for the Advancement of Science (1979); Editorial Advisory Board, *Analytical Chemistry* (1980-1982); NSF's Distinguished Service Award (1980, the Agency's highest honor); Senior Executive Service Bonus (1981, $10,000); Consultant, Procter and Gamble Company, University Exploratory Research Program (1981); Committee on Chemistry of the American Chemical Society (appointed by ACS President in 1982); Senior Executive Service Award (1982, $5,000); Presidential Distinguished Rank (the Government's highest civil service honor, conferred by the President at the White House, November, 1982); Iowa State University Distinguished Alumni Award (June, 1983).

Publications

Twenty-six publications in refereed scientific journals. The publications are in electrochemistry and mass spectrometry. The electrochemical research focuses on the theoretical development and applications of cyclic voltammetry, including computer modeling, and computerized instrumentation. The mass spectrometry involves applications of chemical ionization.

STATEMENT OF DR. RICHARD S. NICHOLSON, ACTING DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY CARL W. HALL, ACTING ASSISTANT DIRECTOR FOR ENGINEERING

Dr. NICHOLSON. Good morning.

Mr. FUQUA. Dr. Nicholson, we're very pleased to have you here this morning.

And if you wish to place your statement in the record and summarize, we'd be pleased with that.

Dr. NICHOLSON. I'd be happy to do that.

I might mention that Dr. Carl Hall has joined me at the table. He's the Acting Assistant Director for Engineering at the Foundation, and prior to that had a distinguished career as dean of engineering at Washington State University.

I might also mention that Carl tells me that the dollar figure for Federal obligations going to support engineering in universities and colleges is about $330 million. So, apparently, it would be about half of the number Dr. Press mentioned to you earlier.

Mr. FUQUA. Is that going into the broad, fundamental programs or more mission-oriented——

Dr. NICHOLSON. Broad engineering research.

Mr. FUQUA. Thank you.

Dr. NICHOLSON. As you know, Mr. Chairman, Dr. Knapp is on official travel today with Dr. Keyworth, and, therefore, sends his regrets that he couldn't testify in person. Similarly, Dr. Branscomb, Chairman of the National Science Board, could not rearrange his schedule, and so he is also unable to appear. So I brought with me written statements from both Director Knapp and Chairman Branscomb, which I will be, as you suggested, happy to submit for the record. And perhaps I can make just a very few summary remarks.

Mr. FUQUA. Yes; we will make their statements part of the record.

[Letters from Dr. Branscomb and Dr. Knapp follow:]

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

March 20, 1984

nsf

OFFICE OF THE
DIRECTOR

Honorable Doug Walgren
Chairman
Subcommittee on Science, Research,
and Technology
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Walgren:

Thank you for the opportunity to comment on the proposed changes in the National Science Foundation (NSF) Act language affecting our engineering program.

With the support and encouragement of your Subcommittee, the Foundation has moved aggressively in recent years to strengthen the engineering program. A major reorganization in 1981 established the Engineering Directorate as a principal unit of the Foundation, with a full divisional structure reflecting the diversity of engineering disciplines. This organizational change has been reflected in increased funding. In FY 1980, our budget request for engineering was $54.3 million. In FY 1985, only five years later, we are requesting $147.1 million, an increase of 170% in current dollars. In addition, engineering schools have been supported for many years by other programs of the Foundation. In FY 1985, support for engineering departments from our Materials Research and Computer Science programs is expected to exceed $60 million. This further demonstrates the strong emphasis that we place on engineering.

In this context, we have no objection to the changes in the NSF organic act proposed by Representative Brown, amended by Representative Skeen, and agreed to by the Subcommittee as a part of the Foundation's FY 1985 authorization act. We do not believe that a major restatement of the Foundation's mission is called for, however, we remain opposed to more sweeping changes in the name or structure of the Foundation without a full debate and consensus in the scientific and engineering communities.

The Foundation's organic act has served us well for more than thirty years. Substantive changes in the Act should be made only after very full consideration. We are pleased to note that the Congress has wisely refrained from frequent revisions of a substantive nature, and we believe that the stability this has provided has had much to do with the Foundation's success.

The Foundation's record in recent years demonstrates the seriousness we attach to our support of engineering. While we have concluded that the proposed changes are not objectionable to the Foundation, we are somewhat troubled by the speed and lack of debate which has accompanied this amendment. Thus we are pleased to have had an opportunity to to state our views thoroughly.

I am enclosing some suggested technical changes in the proposed amendment. We believe these changes would accomplish the intent of the Subcommittee while simplifying the language of the Act significantly. Whether the Congress adopts the amendment or not, the Foundation will continue to develop and strengthen — on the firm basis of merit — our engineering program. I greatly appreciate the past support of your Subcommittee in this regard, and look forward with pleasure to its continuation.

Sincerely yours,

Edward Knapp
Edward A. Knapp
Director

Enclosure

cc: Honorable Don Fuqua
Honorable Larry Winn
Honorable Judd Gregg

TECHNICAL CHANGES TO PROPOSED AMENDMENT

If the Congress were to adopt the proposed amendment, the National Science Foundation believes it could be improved by making the following changes:

NSF ACT SECTION 3(a)(1)

Change section 1 of the proposed amendment to read as follows:

> Section 3(a)(1) of the National Science Foundation Act of 1950 is amended --
>
> (1) by striking out "engineering" where it now appears;
>
> (2) by inserting after "and other sciences" the following:
>
> "and to initiate and support research fundamental to the engineering process and programs to strengthen engineering research potential and engineering education programs at all levels in the various fields of engineering"; and
>
> (3) by inserting ", engineering," after "such scientific".

EXPLANATION:

These changes would accomplish what we believe to be the intent of the amendment without repeating a great deal of language from the present paragraph (1). They also would avoid an unfortunate symbolic separation between science and engineering.

NSF ACT SECTION 3(a)(4)

Change section 2(a)(1) of the proposed amendment to read:

> Section 3(a)(4) of the National Science Foundation Act of 1950 (as redesignated by paragraph (2) of section 1 of this Act) is amended --
>
> (A) by inserting "and engineering" after "scientific"; and
>
> (B) by inserting "and engineers" after "scientists".

EXPLANATION:

The Foundation's role should, as the amendment elsewhere indicates, relate to engineering process and capability, not to development of technology. By the same token, the Foundation should not be charged with a role in the interchange of technological information, as distinguished in some undefined way from scientific and engineering information.

NSF ACT SECTION 3(c)

Change section 2(c) of the proposed amendment to read as follows:

> Section 3(c) of such Act is amended --
>
> (1) by inserting "and engineering" after "scientific" in the first sentence, and
>
> (2) by inserting "and engineering research" after "applied scientific research" in the second sentence.

EXPLANATION:

Section 2(c) as proposed would result in the second sentence of section 3(c) of the NSF Act reading:

> When so directed by the President, the Foundation is further authorized to support, through other appropriate organizations, applied scientific and engineering research relevant to national problems involving the public interest.

We are concerned that the phrase "applied engineering research" could take the Foundation too far towards industrial development or production. The proposed change would have that sentence read:

> When so directed by the President, the Foundation is further authorized to support, through other appropriate organizations, applied scientific research and engineering research relevant to national problems involving the public interest.

We have no problem with the insertion of "and engineering" in the first sentence of section 3(c), because we believe that in the context of on-campus research the parenthetical "including applied research" would clearly not refer to "engineering".

NSF ACT SECTION 3(d)

Change section 2(d) of the proposed amendment to read as follows:

> Section 3(d) of such Act is amended by striking "basic", by striking out "in the sciences", and by inserting in lieu thereof "in science and engineering".

EXPLANATION:

Again, this would accomplish the Committee's apparent purpose in simpler language. It would also make clearer that the Board and Director are authorized to make recommendations on the full range of national policies that affect science and engineering, including, for example, those national policies that affect the level and effectiveness of scientific and engineering research in industry.

NSF ACT SECTION 4(c)

Change section 2(f) of the proposed amendment to read as follows:

> Section 4(c) of such Act is amended --
>
> (1) by inserting "and engineering" after "scientific" in clause (3) of the first sentence;
>
> (2) by inserting "and engineers" after "scientists" in the second sentence; and
>
> (3) by inserting "the National Academy of Engineering," after "National Academy of Sciences," and ", engineering," after "scientific" in the third sentence.

EXPLANATION:

The Committee apparently overlooked the second sentence of section 4(c), added in 1980.

In the first sentence the Committee presumably intends to ensure that engineers are appropriately represented on the National Science Board. A shorter insertion could reflect that intent and have no discernibly different legal effect than the wordier insertion in the current version.

NSF ACT SECTION 8

Strike section 2(g) of the proposed amendment.

EXPLANATION:

The proposed amendment is not intended to direct any change in the current organization of the Foundation. The Director and the Board will surely give "full consideration to the several fields and functions of science and engineering" in revising that organization. The additional words proposed would have no discernible substantive or legal effect.

NSF ACT SECTION 9(a)

Strike section 2(h) of the proposed amendment.

EXPLANATION:

No amendment is necessary here if the Congress, following the Committee's recommendation, adopts the amendment proposed by the Foundation. [Section 7(a) of the Fiscal Year 1985 Authorization, as introduced.]

NSF ACT SECTION 10

Change section 2(i) of the proposed amendment to read as follows:

> The first sentence of section 10 of such Act is amended by striking out "scientific study or scientific work in the mathematical, physical, medical, biological, engineering, social and other sciences" and inserting in lieu thereof "study and research in the sciences or in engineering".

NATIONAL SCIENCE BOARD
WASHINGTON, D.C. 20550

March 20, 1984

Honorable Doug Walgren
Chairman
Subcommittee on Science,
 Research and Technology
Committee on Science and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Doug:

This is in response to your letter of March 15, 1984, requesting my views on the amendment to the NSF Organic Act agreed to by your Subcommittee on March 15.

As the National Science Board has frequently stated in prior testimony, and as the Foundation has demonstrated by creating the Engineering Directorate, by explicitly recognizing engineering in the Science and Engineering Education Directorate, and by the Board's new policy direction for the engineering mission of the NSF, we believe that the support of research and education in both science and engineering should go hand in hand, and the engineering activities of the NSF require strengthening and redirection. While we appreciate that the advocates of a new agency devoted to engineering have focussed national attention on the need to support and modernize U.S. engineering capabilities, especially in universities, the Board has already embarked on this task, and we believe the NSF can achieve it more quickly at less cost and with less danger of raising barriers--already too high--between science and engineering.

This amendment would establish the intent of Congress that the Foundation should proceed with its present course and help replace a sometimes divisive debate in the technical community with a sense of common purpose, which alone can generate the understanding needed for NSF's engineering program to assure U.S. preeminence in engineering without crippling the scientific leadership which must also remain second to none. In this regard, the amendment has much to recommend it.

The Board is also pleased that the amendment agreed to does not go beyond the reality of what the Foundation is able to accomplish, now and in the near future, and represents a significant statement of direction rather than a potentially disruptive upheaval. Indeed, it represents a helpful clarification of language describing the National Science Foundation's mission rather than a basic change in authority.

For over thirty years, "science" has been used in public documents as a generic term including engineering, inter alia, as it does mathematics. While only a few mathematicians have objected to having their discipline subsumed under the word "science," many engineers have felt that the practice tended to deflect attention from the important differences in intellectual tradition and approach of engineering and of science.

Since the Board's new policy for NSF calls specific attention to the need to understand and respond to these differences between "science" and "engineering," the amendment may provide a useful vehicle for developing that understanding of our new directions.

It is my view, however, that the present wording of Section 3(a)(1) does provide clear authority for the NSF's historically substantial engineering activities. The historical debate on the NSF role in engineering had to do with priorities and the evolution of both science and engineering, not with the question whether the Act's reference to engineering in Section 3(a)(1) gave the proper coloration to the word "science." It would be the Board's intention to continue with our current path, whether or not the amendment is adopted, for we believe the intent of Congress and our authority are already clear.

One reason the amendment might help gain understanding for our policy is that we believe there is today a clearer view that "research fundamental to the engineering process" and "programs to strengthen engineering research potential and engineering education" are unambiguously different from the application of engineering capability to achieve commercial purposes or other narrowly focussed applications. Thus it is very important that the language distinguishes between engineering process and capability, versus the development of technology. It was precisely to avoid this confusion, and to assure everyone that engineering and applied research are not synonymous that the Board's first step toward our new policy was to divorce these two activities organizationally in NSF.

For this reason, I recommend that the Committee delete the words "and technological" in Sec. 2, lines 21 and 22 of the amendment, which were proposed to be inserted in Section 3(a)(4) of the Act as redesignated. Similarly, Section 3(c) should read: "...the Foundation is further authorized to support, through other appropriate organizations, applied scientific research and engineering research relevant to national problems...." I am concerned that the phrase "applied engineering research"--itself a contradiction--takes the Foundation too far in the direction of industrial development or production, even under the limitation of a Presidential objective.

In summary, I applaud the Committee's intent and would be happy to accept the amendment in its present form, with the prior minor reservation just given. The Board would, however, be opposed to more sweeping changes in the name or structure of the Foundation without much more public debate and opportunity for all members of the scientific and engineering communities as well as the general public to air their views.

I have seen the technical changes submitted by Dr. Knapp to the proposed amendment and support them. Thank you for giving us the opportunity to share these views with you.

Sincerely,

Lewis M. Branscomb
Chairman

Dr. **Nicholson**. As you know, the engineering mission at the Foundation has had a long, substantive, evolutionary history, both programmatically and in terms of policy.

In the fifties we started out with a very small program that was called engineering and metallurgy. And then in the midsixties, engineering was afforded the status of a division at the Foundation, comparable to, say, physics or chemistry as they are today.

Then in the seventies we had a number of different applied research programs and organizational changes, like the research applied to national needs [RANN] program. These culminated in 1979 with the establishment of a directorate called the directorate for engineering and applied science.

The National Science Board, subsequently, debated the need for a distinct or separate directorate that would be devoted exclusively to engineering, in part to avoid the implication created by the title of the engineering and applied science directorate that engineering and applied science were the same thing. As a result of that debate, the Board recommended that a directorate exclusively devoted to engineering be established, and the responsibility for the support of applied research in both science and engineering be made the responsibility of all the programs across the agency.

And so in 1981 our present structure was created, the engineering directorate.

Discussions about the mission of engineering, nevertheless, have continued since that time. As you know, in 1983 the Board issued a major policy statement about the engineering mission at the Foundation. And in concert with that, the support for engineering has grown steadily over time in the NSF.

For example, in the 5 years from 1980 to 1985, the support for engineering has grown by about 170 percent. Moreover, we support engineering activities in some other parts of the agency where they are integrated appropriately into activities such as materials research and computer science. Engineering related activities in those two areas alone account for about 40 percent of their budget.

As you know, last year, with the support of Congress, we established a Presidential young investigator award, which is a program in direct response to the faculty shortage problem in engineering. This year we have proposed in our budget a new program of engineering centers that is designed to address some of the other problems that have been identified in engineering, such as the need for interdisciplinary research, teamwork experience, the involvement of undergraduates, and the like.

The Board and the Director feel that this history that I've just described, and especially the recent one, provides a track record, so to speak, of the Board and the Foundation being sensitive to and attentive to the needs of engineering, and I should say even providing some good leadership with these new programmatic initiatives.

Accordingly, both the chairman in his statement to you and the Director feel that the proposed changes in this amendment are both consistent and compatible with recent policy and programmatic changes that have occurred at the Foundation. In fact, in that context, they believe the proposed changes are appropriate.

Indeed, Dr. Branscomb remarks in his statement to you, and I quote, "It is the Board's intention to continue with our current path whether or not the amendment is adopted, for we believe the intent of Congress and our authority are already clear."

Finally, both Dr. Branscomb and Dr. Knapp believe that the enabling legislation of the Foundation, the so-called Organic Act, has served the Foundation and the country remarkably well for over 30 years, and they would be opposed to more sweeping, substantive changes in the act without the opportunity for additional public debate and discussion.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Dr. Nicholson.

The question you have heard this morning several times, and I would like to ask your comments on it: If the changes are made in this Organic Act, do you see that there would be an escalation in engineering funding at the expense of science?

Dr. **Nicholson**. No, we do not expect that that would happen. We believe that both are important, both serve very important roles, that there's a certain synergism between science and engineering, and that one wants, in fact, to maintain the opportunity for both science to help engineering and engineering to help science, and one wants the barriers to be lowered. So we would expect that both would be treated appropriately and in a balanced way.

I would say we are very heartened by some of the comments we've heard from members of the committee this morning.

Mr. **Fuqua**. In the National Academy of Engineering report, "Strengthening Engineering in the National Science Foundation," they suggested three important recommendations. One was increasing the number of engineers at policy and program levels; increasing the substructure within the engineering directorate; and increasing the interactions between NSF and other principal engineering institutions in the Government as well as the private sector.

Are any of those suggestions being incorporated into the programs in Dr. Hall's directorate?

Dr. **Nicholson**. Well, I think Dr. Hall is working aggressively on the latter two. In the case of the first question, of course, several of those are Presidential appointees, but I would expect that when those are announced, one will see that kind of attention also.

I don't know if Carl wants to make——

Mr. **Fuqua**. Dr. Hall.

Dr. **Hall**. Good morning.

Within the engineering directorate, we are doing several things to increase the participation of engineers in industry and engineers outside of the Foundation and outside of academia, in fact.

Many of the programs we have, such as the Presidential young investigators awards help to support our efforts. There are 200 of these awards, of which 100 are for engineers. There are even more than that number of engineers being supported through the mechanism that Dr. Nicholson mentioned that is, in other directorates, and industry is involved in supporting these.

You've heard mentioned the engineering research centers program. These will expect involvement of people from industry. In fact, we think the involvement of people will be more important in those, in educating our young engineers, than necessarily money, although some money will be involved.

And then within the programs themselves we are adding industry people and outside people, people with experience across the many areas of engineering, to participate in six advisory committees which we have in the directorate. Also, they will participate as peer reviewers, so that there's industry involvement in the evaluation of the proposals that come to us.

Mr. FUQUA. Thank you.

Mr. Brown.

Mr. BROWN. If I may pursue this for just a moment, with regard to the engineering research centers, this seems to me to be an extremely useful and innovative initiative on the part of the Foundation. And my question has to do with, what do you perceive as being the future development of support for this kind of activity?

Dr. HALL. We're proposing $10 million for support of the first year. I think it's important that we start out on a reasonable level, so that we can develop the procedures, involve all the constituencies, develop and support those which will help meet these problems, and solve these problems.

We would anticipate increasing from about five or so such centers that would be supported this coming year, if the appropriation is provided, to perhaps 25 or 30 in 5 or 6 years down the road.

Again, we're going to have to prove that we can do it. We can prove we can meet a need.

Note that these centers will cut across several disciplines and help undergraduate education. They will help an equipment program, the building of the infrastructure, and the participation of faculty working with industry people in solving major issues.

Mr. BROWN. Well, of course, one of the things I have always appreciated about the Foundation's approach was that, in a sense, they used the scientific method in their development of new and innovative institutional arrangements to further the needs of science. And testing a process like this before expanding it into a larger scale is a very sound procedure.

I am reminded that, in a somewhat similar way, the Foundation pioneered programs for the involvement of small business in research, which proved to be so popular that the Congress tried to run away with that in a very major way by having it mandated on other agencies through the setaside technique.

I'm wondering if you perceive a possible role for other agencies of the Government, mission-oriented agencies, in perhaps adding to the support of this sort of thing in areas specifically related to their mission. Is that a possibility?

Dr. HALL. Yes, indeed. In fact, about a month ago, in meeting with members of the National Academy of Engineering, it was suggested that I take some sort of leadership after we get ours going, if they are supported, and involve representatives from all the agencies. NASA is supporting some of these types of things. Although they are more mission oriented, a portion of them could contribute to the objectives we have here. DOD has some supporting engineering-type programs. The National Bureau of Standards and a few other agencies have at least portions of their activities which would enlarge upon and help us meet the overall objective that was mentioned earlier about cutting across various Government agencies. Yes, indeed.

Dr. **Nicholson**. Mr. Brown, I think we do want to develop the program in a prudent way that Dr. Hall has described, but I would say that the betting is that this program will be a real winner. It has very strong and enthusiastic support by the Board, the Director, and Dr. Keyworth.

Mr. **Brown**. Well, I anticipate it will be well supported by the Congress, also. I'll do my best to do that.

My own perception of the role of the Foundation is very close to what you've described. I think that it should take some leadership in disseminating fruitful innovations into the other agencies of the Government and exercising some degree of quality control over the way these are developed.

Do you agree with that?

Dr. **Hall**. Yes, I do.

Dr. **Nicholson**. Yes.

Mr. **Brown**. Well, I commend you on the initiatives you're taking. I perceive them as making a substantial contribution toward the broader problems that we're trying to solve, and I want to assure you—and I'm sure that the chairman would confirm this—that we want to continue to give you the support that your program merits.

Dr. **Nicholson**. Thank you.

Mr. **Walgren** [acting chairman]. Thank you, Mr. Brown.

And on behalf of the rest of the committee, I want to thank you very much for coming before us today. We appreciate your being a resource to the committee.

Dr. **Nicholson**. Thank you.

Mr. **Walgren**. At this point I want to insert a letter from Dr. Robert M. White, president of the National Academy of Engineering, transmitting the NAE's views on the engineering amendment.

NATIONAL ACADEMY OF ENGINEERING 2101 CONSTITUTION AVENUE, N.W., WASHINGTON, D.C. 20418

Office of the President

March 19, 1984

The Honorable Don Fuqua
Chairman, Committee on Science
and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

I have been informed that you will be holding hearings on the Skeen Amendment to the organic act of the National Science Foundation on Wednesday, 21 March. Unfortunately, it will not be possible for me to serve as a witness. I have been asked by Congressman Doug Walgren, Chairman of the Subcommittee on Science, Research and Technology to present the views of the National Academy of Engineering (NAE). I have done so in the enclosed letter to him. As you can see, the NAE believes that the amendment represents a positive step in strengthening engineering in the NSF. Such strengthening is important to the future industrial productivity and competitiveness of our country and to its national welfare.

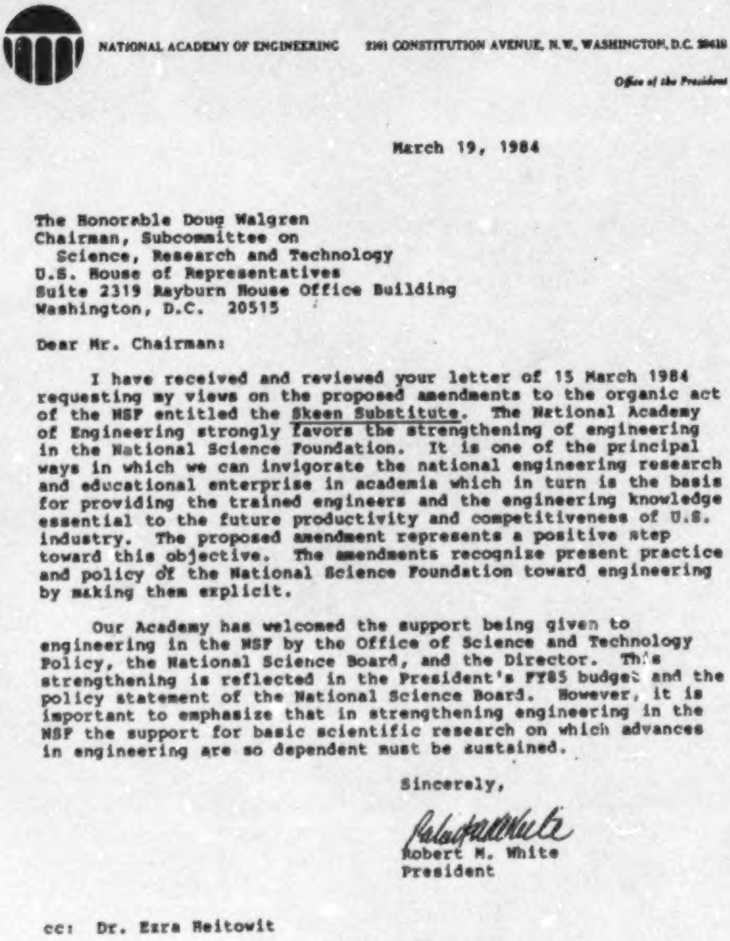
I hope the views of the NAE can be brought before the full Committee as you consider the report of the Subcommitee on Science, Research and Technology.

Sincerely,

Robert M. White

Robert M. White
President

cc: Dr. Ezra Heitowit



NATIONAL ACADEMY OF ENGINEERING 2101 CONSTITUTION AVENUE, N.W., WASHINGTON, D.C. 20418

Office of the President

March 19, 1984

The Honorable Doug Walgren
Chairman, Subcommittee on
Science, Research and Technology
U.S. House of Representatives
Suite 2319 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Chairman:

I have received and reviewed your letter of 15 March 1984 requesting my views on the proposed amendments to the organic act of the NSF entitled the Skeen Substitute. The National Academy of Engineering strongly favors the strengthening of engineering in the National Science Foundation. It is one of the principal ways in which we can invigorate the national engineering research and educational enterprise in academia which in turn is the basis for providing the trained engineers and the engineering knowledge essential to the future productivity and competitiveness of U.S. industry. The proposed amendment represents a positive step toward this objective. The amendments recognize present practice and policy of the National Science Foundation toward engineering by making them explicit.

Our Academy has welcomed the support being given to engineering in the NSF by the Office of Science and Technology Policy, the National Science Board, and the Director. This strengthening is reflected in the President's FY85 budget and the policy statement of the National Science Board. However, it is important to emphasize that in strengthening engineering in the NSF the support for basic scientific research on which advances in engineering are so dependent must be sustained.

Sincerely,

Robert M. White
President

cc: Dr. Ezra Heitowit

Mr. WALGREN. And that ends the hearing. Thank you very much.

[Whereupon at 11:46 a.m. the committee recessed to reconvene at the call of the Chair.]

APPENDIX

NIET The NATIONAL INSTITUTE
For ENTREPRENEURIAL TECHNOLOGY

Philip Speser, J.D., Ph.D.
Executive Director

GREATER NSF SUPPORT FOR UNIVERSITY/INDUSTRY PROGRAMS URGED

Statement of the National Institute for Entrepreneurial Technology

on the

FY 1985 National Science Foundation Budget Request

A thriving system of scientific and engineering research and educational institutions, when encouraged to interface with industry, provides a vital part of the infrastructure needed for economic growth. University/industry linkages play a major role in stimulating rapid transitions from fundamental scientific and engineering research to practical implementations of innovations. Encouraging the formation of such linkages must be a vital element of Federal Government efforts to stimulate a renaissance of our industrial competitiveness on world markets. The National Science Foundation (NSF) has played, and can continue to play, a role in facilitating these linkages through direct and indirect funding programs.

It is widely recognized that corporate return-on-investment calculations will undervalue the benefits derived from basic and applied research. No individual firm can capture all of these benefits for itself. Investment levels which may be rational for individual companies, however, are not necessarily rational for the country. The challenges presented by Japanese and European technology on world markets highlight the importance of stimulating new partnerships between the elements of our national science and technology system.

The NSF Industry/University Cooperative Research Centers and Cooperative Research Projects programs, in the Division of Industrial Science and Technology (ISTI), are excellent examples of how direct funding programs can stimulate linkages. These programs are leveraging private-sector funding for basic and advanced research. This benefits American companies which require knowledge and highly educated employees to develop new products and manufacturing processes. It benefits universities by providing new sources capital of for researchers and students. At the same time the inclusion of program evaluations as on-going components of program management, have contributed greatly to our knowledge of the innovation process and to more effective Federal Government roles in that process.

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Without Federal seed money, this synergism would likely not have occurred. Increased funding should be provided to expand ISTI programs so that they may fine-tune their existing operations on the basis of program evaluations and explore alternative models for encouraging industry/university linkages.

NSF can also stimulate better university-industry relations through its Small Business Innovation Research (SBIR) Program. This program, the model for P.L. 97-219, is making a major contribution to the formation and growth of our country's high-technology industries.

We urge the Committee to increase the funding for ISTI by $3.15 million, $1 million each for Industry/University Cooperative Research Projects, the Industry/University Cooperative Research Centers Program, and Productivity Improvement Research. These funds should be used to explore new models and to fund projects and centers designed to speed the transition from academia to commercialization in supercomputers and biotechnology and to conduct additional research on problems of innovation in automated manufacturing and on the implementation of technological innovations in general. An additional $150,000 should be provided for handling the increased administrative burden that has resulted from proposal pressure on the SBIR program. In addition, we urge report language which would direct NSF to explore partial early payment and other means of enabling start-up firms with limited cash flow to participate in the program.

Direct funding programs alone are not sufficient. The development of thriving high-technology businesses around Palo Alto and Boston indicate the importance of the presence of major science and engineering research universities for the formation and growth of high-technology companies. Survey research sponsored by Congress, Federal agencies, and organizations such as the National Institute for Entrepreneurial Technology repeatedly confirm the importance of the presence of major universities for the formation and growth of high-technology firms. Adequate funding for university science and engineering research and education is a second mechanism for stimulating consulting, internship, licensing, and other university/industry linkages.

Federal funds account for over 66% of all academic R&D and are by far the largest source of R&D funds for almost all academic institutions. Unfortunately, Federal R&D funding for universities is excessively concentrated. As a recent NSF-funded study by Edward Malecki points out, the top 100 academic institutional recipients of Federal R&D funds account for over 82% of total funds going to such institutions. Yet these institutions are located in only 36 states (including the District of Columbia) with 62 of the top 100 in 12 states. Indeed 10 states receive over 56% of Federal R&D obligations for universities.

Such concentration is unfortunate. It inhibits the development of national centers of scientific and engineering research and education in all parts of the United States. Concentration means that technological creativity and innovation is inhibited by the lack of an adequate research and education infrastructure for these activities.

The solution to concentration is not to withdraw funding from existing national centers. Rather, additional funds should be made available to support research and education in order that existing state and regional universities may be upgraded into national centers. Such funding should be provided in a manner which encourages linkages between universities and firms of all sizes.

We urge the Committee to support the NSF request for Centers for Cross-Disciplinary Research in Engineering. We also request that the Committee include language in its report urging NSF to model funding for these Centers on the approach developed by the Industry/University Cooperative Research Centers in order to ensure such centers strive for financial self-sufficiency.

A thriving system of universities -- linked to small, medium, and large companies -- is essential for long-term economic growth. The spirit of inquiry and innovation that such a system creates is a national resource.